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HAWAII AGRICULTURAL EXPERIMENT STATION,
HONOLULU, HAWAII.
J. M. WESTGATE, Agronomist in Charge.

Under the supervision of the STATES RELATIONS SERVICE,
Office of Experiment Stations, U. S. Department of Agriculture.

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REPORT OF THE HAWAII AGRICULTURAL EXPERIMENT STATION.

1921.

Issued, September 12, 1922.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1922

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[Under the supervision of the States Relations Service, United States Department of Agriculture.]

A. C. True, *Director.*
E. W. Allen, *Chief, Office of Experiment Stations.*
Walter H. Evans, *Chief, Division of Insular Stations, Office of Experiment Stations.*

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R. A. Goff, *In Charge of Glenwood Substation and Extension Agent for Island of Hawaii.*
Nellie A. Russell,[2] *Collaborator in Home Demonstration Work.*

LETTER OF TRANSMITTAL.

Hawaii Agricultural Experiment Station,
Honolulu, Hawaii, July 22, 1921.

Sir: I have the honor to transmit herewith and to recommend for publication a report of the Hawaii Agricultural Experiment Station, 1921.

Respectfully,

J. M. Westgate,
Agronomist in Charge.

Dr. A. C. True,
Director States Relations Service,
U. S. Department of Agriculture, Washington, D. C.

Publication recommended.
A. C. True, *Director.*

Publication authorized.
Henry C. Wallace,
Secretary of Agriculture.

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[1] Appointed July 1, 1920.

[2] Appointed on part-time basis Nov. 1, 1920.

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REPORT OF THE HAWAII AGRICULTURAL EXPERIMENT STATION, 1921.

SUMMARY OF INVESTIGATIONS.

By J. M. Westgate, *Agronomist in Charge.*

INTRODUCTION.

During the fiscal year 1921 the station continued to devote the major part of its energies toward the development of investigations which it is thought will assist most tangibly in furthering the diversified agricultural industries of the islands. Both the sugar-cane and the pineapple industries have developed to such an extent commercially that their producers are now able to finance private experimental work. The smaller industries, however, not yet having reached this financial stage, are still dependent upon the station for experimental work that must be done to enable them to develop to desirable proportions. The rice, banana, and starch-producing industries are all deserving of and receiving special attention and interest, because they furnish staple food supplies which can be exported in normal times and used to feed the local population in the event of interruption to shipping. The station is also giving attention to the production of taro, which is one of the staple food crops of the native population.

On account of the extremely high prices obtaining in 1919 and 1920 for sugar and pineapples, the area planted to these crops was increased during the year and a proportionately less acreage was left for the production of the diversified crops. The new areas are largely the upper lands that had not been devoted to crops of any kind owing to lack of water for irrigation and the expense of clearing the guava and lantana bushes covering them.

The station continued to make experiments in drying and canning local fruits and vegetables for the purpose of eliminating the waste of certain perishable food products and of furnishing a profitable outlet for their utilization when the fresh materials are out of season. These experiments are deemed necessary because the local demand for any food product is limited, and a slight overproduction usually gluts the market, resulting in waste. Experiments were also undertaken for the production of starch from such plants as edible canna, tree fern, cassava, sweet potato, Irish potato, and banana.

BUILDINGS AND GROUNDS.

During the year some landscape gardening was done on the station grounds. This work included the shifting of inconveniently routed roadways and the planting of hedges and ornamentals. A number of the station buildings received their first coat of paint since before the World War, and the photographic dark room in the horticultural building was refitted, special equipment being installed for taking natural-size photographs of fruits and other products.

MAUI COUNTY AGRICULTURAL FAIR.

The third annual Maui County Agricultural Fair, which was held from October 21 to 23, inclusive, again emphasized the diversified agricultural features of the islands, especially the production of fruits, vegetables, and various kinds of feed for live stock. The station made exhibits of some of the salient features of its work along horticultural, agronomic, and extension lines. A representative of the station was in charge of the booth at all times to answer questions. Many people were interested in the work of the station and numerous requests were received for planting stocks of improved varieties of farm crops, vegetables, and fruits.

HORTICULTURAL INVESTIGATIONS.

The appointment of Willis T. Pope as horticulturist of the station resulted in some change in the projects of the horticultural division, although the older and more permanent investigations were continued essentially as outlined in the past. Among the latter investigations are those with bananas, papayas, mangoes, avocados, and citrus fruits, special attention being given to the production of bananas, avocados, and papayas, which have high commercial value at the present time. New areas are being opened up for the production of bananas, and plans are under way for the utilization of the smaller bunches which are not adapted to shipping. It is planned to convert them into edible fruit products by drying or other process, so that they can be either shipped or used locally.

In the work with avocados there have been developed combinations of orchard plantings which will make possible the gathering of these fruits every month in the year. Owing to its high oil content, which varies from 8 to as high as 29 per cent, the avocado fruit is difficult to preserve in a palatable condition. However, there is some possibility of success along this line, and it is also likely that a satisfactory salad oil can be manufactured from the fruits that can not be more profitably utilized.

During the year the viticultural experiments were transferred from Wahiawa, on the island of Oahu, to the station grounds at Honolulu. A number of varieties of promising grapes have been obtained, including the famous Corinth seedless grape, which is the source of most of the dried currants of commerce. This variety may prove of great value to the Territory, especially if it can be made to produce satisfactorily on the otherwise unused steep slopes and ridges which are numerous throughout the islands. Such conditions are said to be similar to those in Greece, where the currant grape has been under cultivation for many hundreds of years.

Experiments with numerous varieties of pohas, the local name of the husk tomato or ground cherry, indicate that no variety is so desirable for jam making as the wild poha (*Physalis peruviana*) of the mountainous districts.

The horticultural division has kept in touch with the public by means of the local press and by numerous distributions of propagating material of improved fruits and vegetables. In one instance, the publishing in a local newspaper of a brief article concerning the planting material which could be had at the station on a certain day resulted in 121 personal calls during that day for the planting material, together with numerous inquiries by letter for plants, cuttings, and seeds.

AGRONOMIC INVESTIGATIONS.

Agronomic investigations, as in the past, were directed principally to the further production of various field crops for animal and human consumption. The distribution of seeds, cuttings, and tubers of improved varieties continued to be an important phase of the division's activities. The variety tests of sweet potatoes, Irish potatoes, and taro were continued both at the central station and in cooperation with a number of ranches and plantations. The grain investigations were confined largely to corn, and an especial attempt was made to hybridize the white Guam corn with some yellow varieties to obtain a variety having the desirable characteristics of the Guam corn and the yellow color demanded by the local market. A very satisfactory start has been made in this experiment and there have been obtained yellow ears of the desired type which it is hoped will be possible to fix by rigorous selection. A number of other varieties of corn have been under test, but none seem to do as well at low elevations as the Guam and Cuban varieties. Tests were made with sweet corn, the varieties Pocahontas Early, Henderson Sweet, and Golden Bantam giving promising results at the central station. Most varieties of sweet corn do not succeed at the lower levels in the Hawaiian Islands.

The local production of forage crops continued to be an interesting and important line of work, and the soiling crops which received the most attention were Napier or elephant grass (*Pennisetum purpureum*), Merker grass (*P. merkeri*), and Uba or Japanese sugar cane. These crops are proving valuable at the local dairies, and also on the plantations where up-to-date dairies are being installed to supply the laborers with milk for their families. Of the legumes, the kudzu vine (*Pueraria thunbergiana*) received the most attention. Cuttings of this vine have developed into large-sized, vigorous plants at the station much more rapidly than have seedlings. However, it is likely that the vigor of the plants grown from cuttings was due to some inherent character in the plant, and not to the planting of cuttings.

POULTRY WORK.

Owing to the numerous demands made upon the station for assistance in solving the many problems arising in connection with the poultry industry, the station deemed it necessary to devote some attention to this line of work. There is no poultry plant at the station, but feeding experiments and demonstrations were carried on with the flocks of various members of the staff. It is felt that a large amount of experimental work will have to be carried on with poultry before the numerous problems now confronting poultrymen in Hawaii can be solved.

CHEMICAL INVESTIGATIONS.

The work of the chemical division during the year was largely devoted to carrying to completion experiments that had been started during the previous year and to the launching of a new experiment having for its object the utilization of tree-fern starch. This product has many qualities to commend it. When cooled it has that opalescent appearance so characteristic of arrowroot. It has a clear, smooth consistency and a palatability and variety of uses that should make it a ready sale.

The analysis of Hawaiian starches and residues therefrom indicate that starch of excellent purity for household use can be prepared from Hawaiian root crops with simple, inexpensive apparatus. However, there is need for further study to determine the most effective methods of shredding and extracting because of the high starch content of the residues.

Cooperative fertilizer experiments with large growers were carried on with pineapples, bananas, upland sugar cane, and pigeon peas.

An experiment undertaken for the control and eradication of the pineapple wilt was concluded during the year. This was an attempt to find some disinfectant which when applied would kill the attacking organism without vitally injuring the pineapple plant. The test failed to reveal a satisfactory disinfectant or combination of disinfectants.

Preliminary investigations were begun to determine the resistance of various local crops to varying amounts of salt in the irrigating water. Sufficient progress has not been made to permit of a report this year.

AGRICULTURAL EXTENSION WORK.

The work of the extension division was carried on along essentially the same lines as in past years. The resignation of the superintendent of extension, effective early in the next fiscal year, has necessitated the closing up of certain lines of extension activity which he is particularly adapted to manage. The operation of his personally owned farm as a demonstration and experimental farm will necessarily cease. Fortunately, however, the experiments have been carried to a practical consummation during the seven years the farm has been in operation. This farm has served as a model to all the homesteaders in the islands and the demonstrations have been beneficial to the small farmer and the large plantation owner, both of whom have frequently called upon the superintendent for his advice and assistance.

The further aim of the extension division is to develop club work for boys and girls, as well as cooperative organizations to solve the problems connected with marketing and shipping, to stabilize and standardize market products, and to study the market requirements. It is very evident that the problems of marketing farm crops are just as important as are those connected with the production end of the farming business.

The collaborators have continued to give satisfactory service in acting as representatives of the station in their respective districts and in lending their influence to the various agricultural activities which needed developing. The superintendent of extension acted as adviser to many of the up-to-date plantation owners who were endeavoring to develop a number of dairy projects. These men realize the advisability of supplying large quantities of wholesome milk to the growing families of their employees, and consulted the superintendent regarding the best breed of dairy cattle for Hawaiian conditions, the most profitable equipment for the dairy, and the best method of planting fields for the continuous production of nutritious forage for cows.

The swine industry received attention, and emphasis was laid on the adaptability of the Berkshire breed to island conditions. The herds of hogs at the Haiku substation and demonstration farm served to demonstrate the possibilities of this breed.

An important feature of the extension work during the year was a series of lectures and demonstrations given in cooperation with other local agricultural agencies on the islands of Hawaii, Kaui, and Maui.

HOME DEMONSTRATION WORK.

Home demonstration work was started on a small scale by an experienced home economics demonstrator who worked part time as collaborator. Hawaiian fruits and vegetables, canned, preserved, and made into jams, jellies, and marmalades, were collected for exhibition and demonstration purposes. This collection was given wide publicity, some of the material being exhibited in the leading stores. Cooking demonstrations were held at various women's clubs and other organizations. Demonstration meetings were held in Honolulu and also on the sugar plantations for the benefit of the wives of the plantation employees who did not find it convenient to attend the demonstrations given in the more densely populated centers.

EXTENSION WORK ON THE ISLAND OF HAWAII.

The extension work of the island of Hawaii, the largest island of the group, is under the immediate charge of the extension agent for that island. During the year the agent was able to keep in reasonably close touch with all the lines of diversified agricultural activity. He also assisted the small farmer in making trial shipments of bananas from Hilo to San Francisco direct and by way of Honolulu. In addition to his other activities the extension agent acted in the capacity of general superintendent of the Glenwood demonstration farm, which is operated by a collaborator living on the farm. The work of this farm was directed principally to the raising of poultry to determine by selection the best egg breeds for Hawaiian conditions. A flock consisting of 300 laying hens was trap nested[1] so that it might be learned which varieties are the best layers, and eggs from the best hens were sent for settings to homesteaders and poultrymen in various parts of the islands of Hawaii, Maui, and Oahu. A small herd of Berkshire pigs is being maintained at this farm, together with a dairy herd, which was materially increased by births during the year.

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[1] A trap nest is one so arranged as to confine a hen after she enters until she is released.

Demonstrations in budding and grafting seedling fruit trees with improved varieties were popular phases of the work of the year. In connection with the forage crop extension work, plats for demonstration purposes were planted in alfalfa, elephant grass, and pigeon peas, the plantings being made mostly on plantations where dairies are being installed.

The school and home garden activities were again successfully carried on. Attention was given to the agricultural phases of the boy scout work, and demonstrations of various kinds were made for the benefits of those boys who were working for the merit badge in agriculture.

HAIKU SUBSTATION AND DEMONSTRATION FARM.

At the Haiku substation and demonstration farm large plat demonstrations were made and a great amount of experimental field work was carried on. Special attention was given to the growing and feeding of new and improved forage crops which gave the best results in comparative tests made at the central station. The principal forage crops under test were the Yellow-Tipped cane, Uba cane, Napier or elephant grass, and Merker grass, all of which make desirable dairy feeds when they are cut and fed in the green stage.

Pigeon peas.—The distribution of pedigreed farm seeds continues to be an important phase of the station's work. During the year enough seed of the improved pigeon peas was distributed to responsible growers to plant 4,000 acres. This distribution was made by people who obtained the original seed stocks from the Haiku substation.

Sugar-beet work.—A variety test was made with beets during the year to determine their yield and sugar content, which was found to be high.

Pineapple experiments.—Experiments with pineapples have been under way since 1914. From them a great deal of valuable data have been obtained for the use of pineapple growers and packing companies. The experiments included both fertilizer and cultural investigations, and have shown that the type of soil and its humus and drainage conditions have more to do with the maximum production of the pineapple plant than have the kind and amount of fertilizer used.

Tests with starch-yielding plants.—Experiments with such root crops as edible canna (*Canna edulis*), cassava, sweet potatoes, and Irish potatoes were made to determine their value as starch yielders. Among other things it was found that the waste products remaining after the starch has been extracted make very good constituents of mixed feeds for farm live stock, and also that 5,200 pounds of these starch residues have a feeding value equal to that of 2,000 pounds of shelled corn.

Live-stock work.—The live-stock work of this station includes breeding and feeding experiments with goats, swine, and dairy cows. The breeding animals are frequently loaned to interested farmers in various parts of the islands for the purpose of upgrading their stock. It is hoped that the station's purebred Toggenburg buck will be effective in materially building up the virile native stock as milk producers.

MISCELLANEOUS SUBSTATIONS AND DEMONSTRATION FARMS.

The station maintains substations on the islands of Hawaii, Oahu, and Maui for the purpose of carrying on work which can not well be undertaken at the central station. The Glenwood substation and demonstration farm, on the island of Hawaii, is being operated as a poultry, pig, and dairy farm, and the Tantalus substation, on the island of Oahu, for the purpose of obtaining data concerning the behavior of crops, especially tropical fruits, at a higher elevation (1,000 feet above sea level) than can be had at the central station.. The Haleakala substation and demonstration farm on the island of Maui has made numerous variety tests with corn, potatoes, and other farm crops. The pigeon pea is proving especially valuable as a poultry feed and as a protection to poultry from the wind and sun.

REPORT OF THE HORTICULTURAL DIVISION.

By W. T. Pope.

INTRODUCTION.

The principal work of the division of horticulture included the reorganization of the projects which have been in progress during the past few years, and which were found to be of special importance during the World War, when immediate food production became a pressing problem. This division is now turning to the more general plan of work formerly followed by the station in its effort to improve horticultural practices throughout the Territory.

Some leading points in this plan are the introduction of new plants which it is hoped will prove of economic value in Hawaii; an endeavor to improve the useful plants that are already growing on the islands; and the propagation and distribution of new and improved plants and seeds to people wishing to grow more and better fruits and vegetables. The work of the year was enlarged by the dissemination of useful information that was gained by experiments and otherwise. This has involved many interviews and the preparation of manuscripts for printed circulars and newspaper articles dealing not only with direct horticultural problems, but with associated subjects, such as plant diseases and insect enemies.

Many things indicate a growing interest in agriculture in Hawaii. For instance, the number of requests for plants and seeds, which the station has for distribution in connection with the experimental work, is far greater than can be supplied. No doubt this increasing interest is due in part to the reduction in plant loss caused by insect pests. The changed conditions brought about by the World War have been the means of convincing many people of the necessity of increasing the food crops and the advisability of maintaining a home garden for the production of fruits and vegetables for home consumption.

AVOCADOS.

Avocado investigations at the Hawaii station have been in progress practically since its establishment in 1901. Some of these experiments have brought to light very valuable information, a considerable part of which was published as a bulletin of the station.[2]

At the present time there is a wider interest than ever before in the growing of this fruit, both in tropical America and on the mainland of the States. Doubtless the demand for a more diversified food production has resulted in giving more time to the study and culture of this useful fruit. Recent investigations made by the United States Department of Agriculture, through its plant explorers, have revealed many facts regarding the possibilities of the avocado, some of which were formerly unknown in the States.

The composition of the avocado varies greatly with the variety, as is indicated in the following table:

Composition of avocado varieties under test at the Hawaii station.[1]

Variety.	Water.	Protein.	Fat.	Carbohydrate.	Ash.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Trapp	78.66	1.61	9.80	9.08	0.85
Solano	90.62	1.27	3.64	3.64	.62
Northrop	66.31	2.36	23.00	7.12	1.21
Harmon	71.58	2.50	19.33	5.32	1.27
Fuerte	60.86	1.25	29.14	7.40	1.35
Puebla	63.32	1.80	26.68	6.64	1.56
Taft	....	....	18.50	....	....

[1] From California Sta. Bul. 254, and other sources.

Individual trees possess widely varying characters, such as different seasons for fruiting in different localities of the same country, and different sizes, shapes, and flavors of fruit. These characters will probably lead to the standardization of varieties of quality for extensive use. The avocado is believed to have a fairly high food value, and is considered to be one of the greatest sources of food produced in the Tropics at the present time. In Central America it is used extensively as a substitute for meat.

---

[2] Hawaii Sta. Bul. 25, The Avocado in Hawaii.

Wilson Popenoe, plant explorer of the Bureau of Plant Industry, United States Department of Agriculture, estimates that the total area devoted to avocado culture in California, Florida, Cuba, and Porto Rico approximates 1,000 acres. In California the avocado growers have formed a cooperative organization for the purpose of carrying out their work more efficiently. Many varieties have been tried, and those of fine quality have been recommended for planting. During the summer and autumn avocados are regularly found on the markets of several of the larger cities in the States, and their value as a highly nutritious fruit is rapidly becoming known.

Conditions for avocado culture were unsatisfactory at the central station, and the plantings of recent years have been transferred to the Tantalus substation, where the climate is cooler and the rainfall greater. Moreover, the soil is deeper and richer at the latter place, and the elevation is about 1,000 feet. The first plantings were made over two years ago and have been extended from time to time. The trees in this orchard include many local varieties and 22 varieties of the Popenoe collection in Guatemala. Young budded trees are being developed from budwood that was recently obtained from the Bureau of Plant Industry, United States Department of Agriculture. The varieties represented in this collection are in part those that have gained a reputation in Florida and California for their hardiness, productiveness, and choice qualities of fruit. Some excellent additions in both local and foreign varieties have been furnished the station by interested citizens.

The objects of the avocado investigations are (1) to determine the best conditions for the culture of the avocado in the Hawaiian Islands; (2) to test a number of varieties with the hope of being able to select a group maturing high-grade fruit throughout the year; (3) to encourage the culture of budded varieties so that there will be established a standard fruit for commercial purposes as well as for the home orchard; (4) to determine by experiment the best methods of control of insect pests and plant diseases; and (5) to solve the cause and determine a remedy for the untimely dying of avocado trees in many parts of the islands.

AVOCADO CLASSIFICATION.

The station has made a start in the classification of avocados, using the system established by Popenoe.[3]

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[3] Manual of Tropical and Subtropical Fruits.

The genus Persea, to which the avocado belongs, is a member of the laurel family (Lauraceæ), and is related to the cinnamon tree, camphor, and sassafras.

Careful study of cultivated avocados show that they are derived from two species which are briefly described as follows:

Persea americana, which is also know by some authorities as *P. gratissima*, includes all the varieties known horticulturally as belonging to the West Indian and Guatemalan races. This species is the common avocado of the tropical American lowlands, and the one which has been most widely disseminated throughout the Tropics. Most avocados in the Hawaiian Islands belong to it.

Persea. drymifolia, designated by some as *P. americana* variety *drymifolia*, includes the small avocados of the Mexican highlands. This great group has been cultivated to very little extent in other countries, and only very few trees of the group are to be found in Hawaii.

A third species, *P. schiedeana*, commonly known in its native country as the "coyó," or "chinini," is of recent introduction. It is indigenous in southern Mexico and a part of Guatemala, and as yet is of no consequence outside of these countries. A sample tree is now growing at the Hawaii station.

Seedling avocados of the above-mentioned species vary in habits of growth, particularly in relation to the fruit. The fruit of the common avocado (*Persea americana*) varies greatly in size, shape, color, and quality.

Variations in the *P. drymifolia*, the Mexican race, are most marked in the small size of the fruit and the anise-like odor of the leaves.

These species as cultivated in parts of the States are horticulturally grouped into three races or species, based on certain well-marked, differentiating characters which propagate true to seed, with possibly the exception of simple fluctuating variations. The classification of avocados into these three races is useful because it brings together all of the varieties having several characters in common. In fact, the mere statement that an avocado belongs to the West Indian, Mexican, or Guatemalan race gives the idea of the relative hardiness, season of ripening, and commercial characters of the fruit. The key to the racial characters of the two important species follows:

(1). *Persea drymifolia:* Mexican race. Leaves anise-scented; skin of fruit thin (rarely more than one-thirty-second inch thick).

(2) *Persea americana:* Leaves not anise-scented; skin of fruit thicker (from one-thirty-second to one-fourth inch thick:

  (*a*) Fruit, West Indian race. Summer and fall ripening; skin usually not more than one-sixteenth inch thick, and leathery in texture.

  (*b*) Fruit, Guatemalan race. Winter and spring ripening; skin one-sixteenth to one-fourth inch thick, and woody in texture.

AVOCADO DIE-BACK.

The cause of and the remedy for the early death of avocados in the islands has been much discussed but the losses continue as heretofore. The complaints of losses of trees are very frequent. The chief symptoms of trouble are briefly: (1) The dying back of branches, resulting in the death of the tree[4]; (2) in most cases the leaves turn yellow and drop off, the green branches wilt, become hollow at the pith, turn brown, and slowly die back into the trunk; (3) the roots when examined have a lifeless appearance; and (4) often trees die quickly when they are laden with fruit.

The disorder is not necessarily confined to the avocados of Hawaii. It has recently been reported as a common malady of the avocado on the island of Tahiti and also on other islands of the Pacific.

Die-back of the avocado has been overcome to some extent in the milder forms of attack by pruning out the dead parts of the top and feeding the roots thoroughly rotted barnyard manure and an increased supply of water. The present indications are that the difficulty is due to a combination of causes. In the first place, the avocado is what may be called a tender tree, because it is susceptible to disorders if conditions are not right. It can not stand poor soil conditions, such as poor soil drainage, too much volcanic sand or a layer of rock, or an insufficient water supply in dry weather. The greatest number of trees are lost during dry periods of the summer. Die-back may be prevented by giving the trees good culture, taking care to plant them in a location that is not only well sheltered from hard winds but that has a soil rich in organic matter and a good underdrainage.

COOPERATIVE EXPERIMENTS.

Avocado experiments made in cooperation with private growers were started in 1919 and 1920 and are still in progress. Several of the plantings are doing very well and others have not made satisfactory growth.

AVOCADO VARIETIES UNDER TEST.

Many varieties of avocados are under test at the central station and at the Tantalus substation, a mile up the mountain from the central station. Among them is a new variety of great promise, the Taylor (station No. 4639), the origin of which is a seedling growing in the Kaimuki district, Honolulu. (Pl. I, Fig. 1.)

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[4] Die-back may begin at any age. It occurs most commonly about the time the young trees first come into bearing. It has not been traced to insect pests, nor to any sort of plant disease.

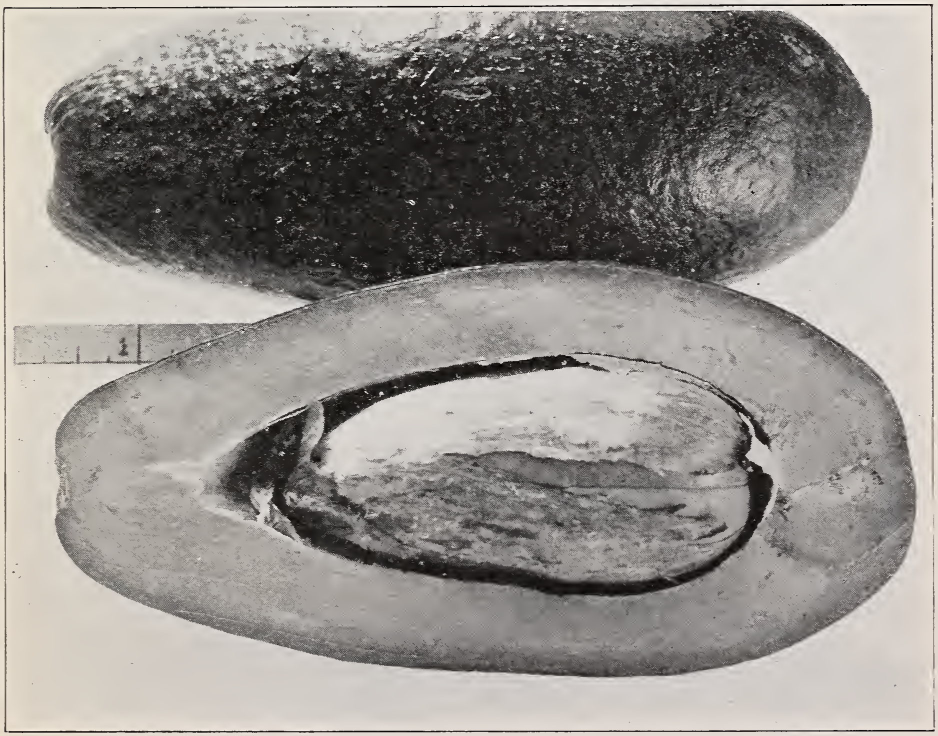

FIG. 1.—TAYLOR AVOCADO. A SEEDLING GROWN AT KAIMUKU, OAHU.

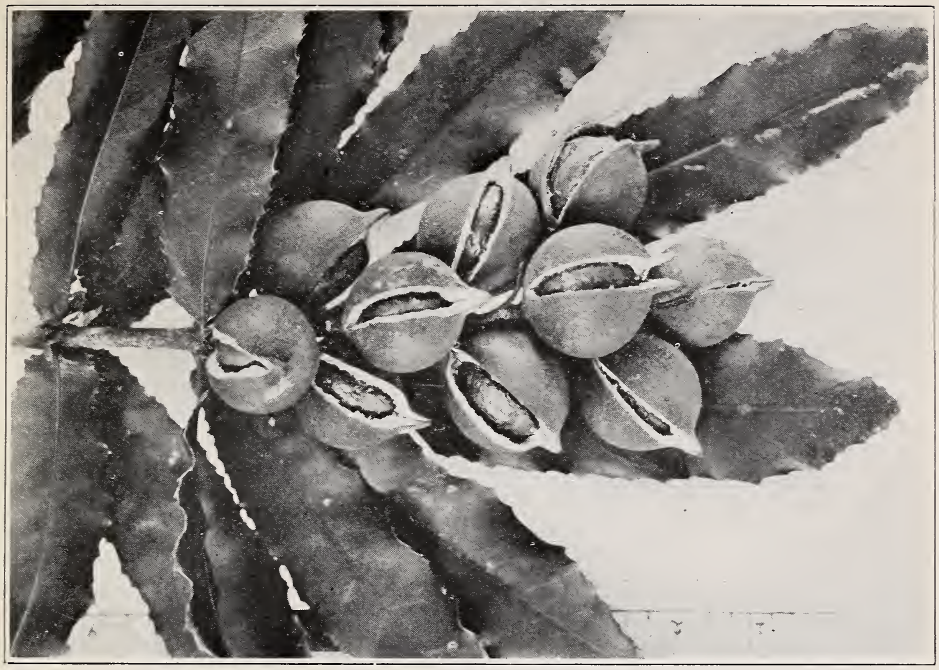

FIG. 2.—CLUSTER OF MACADAMIA NUTS APPROACHING MATURITY.

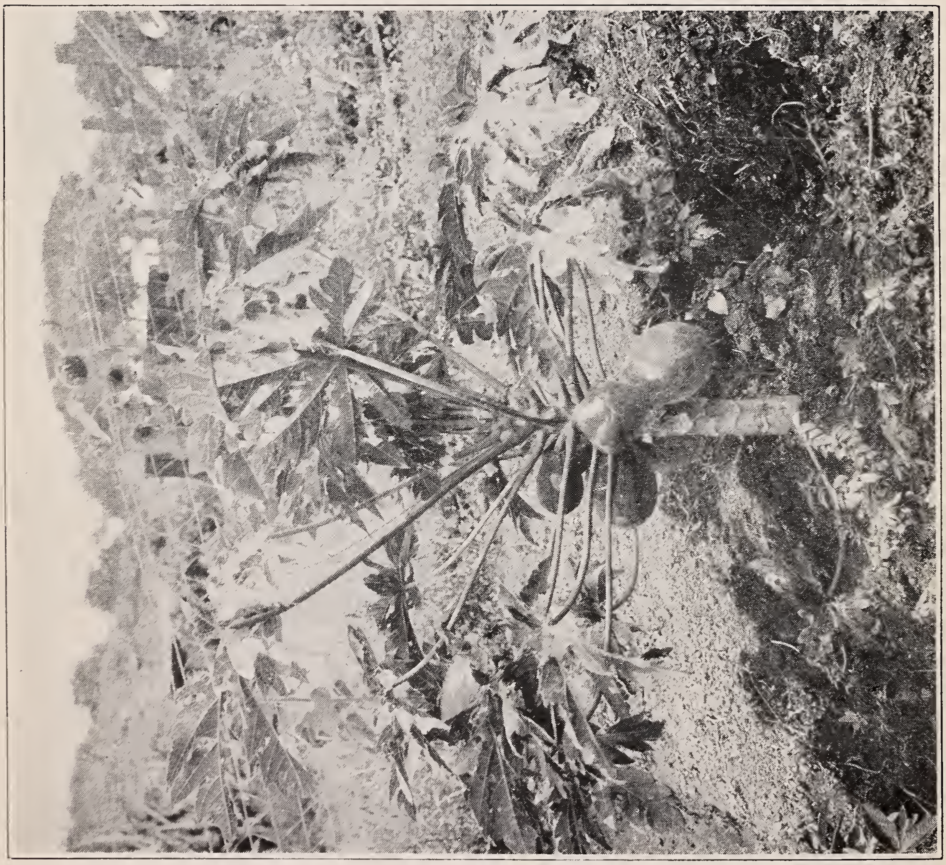

Fig. 1.—Dwarf papaya from root cutting. Grown by Mrs. Della Shaw, Manoa Valley, Oahu.

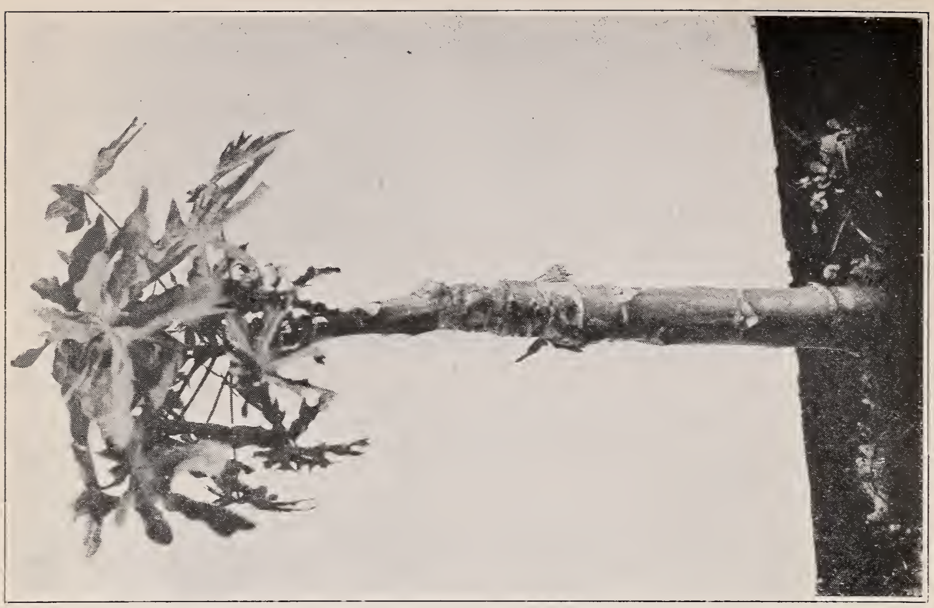

Fig. 2.—Grafted papaya tree, 4 months after grafting. Station grounds.

BANANAS.

The Hawaiian Islands have many advantages for the growing of bananas. Both the soil and the climate are admirably adapted to the cultivation of this highly nutritious fruit; the Territory is free from tornadoes which do considerable damage to banana plantations elsewhere, and the winds are seldom so strong as to blow the plants over; and the plant as it grows in these islands has very few enemies such as diseases and insect pests. This fruit is one of the most extensively used tropical fruits in the Temperate Zone and has a wide range of uses in its natural clime. Many varieties are grown in Hawaii, some of which are hardly profitable for shipping to the cooler climates.

Banana growing as an industry in Hawaii dates back to about 1864, when the first exportations were made. Since that time the industry has made slow growth, but the commercial production now amounts to about 200,000 bunches annually. The industry has been seriously handicapped in the past by the lack of proper shipping facilities. The development of proper shipping facilities has been retarded by the competition which the fruit has met with in the markets of the mainland where Central American grown bananas are sold. The local industry has remained relatively small. The plantings are increasing, however, and the demand for offshoots is greater than the supply. From $25 to $50 per 100 is being paid for them. Offshoots of some of the commercial varieties can not be obtained on the market.

Investigations were undertaken by the station for the purpose of improving the banana industry in every way possible. As a preliminary step, a survey was made to ascertain how many acres in the Territory are devoted to banana growing. Approximately 262 acres are under cultivation with 800 plants to the acre. Each plant normally produces one bunch annually. The investigations further showed that there are hundreds of other acres which could be made to yield an abundant crop of bananas annually, since these lands are not used or are not suitable for the growing of either sugar cane or pineapples.

The station selected two new locations for the planting of a number of varieties which are to be grown under different conditions so that results may be carefully studied and records made of the tests. One location consists of 1½ acres in a sheltered valley at the Tantalus substation. This area is largely terraced land that was covered with various kinds of trees, including coffee, rubber, tea, and seedling avocados, all of which had passed their usefulness. Large holes were made 8 feet apart on the terraces and as fast as new offshoots could be obtained they were planted in them. Much effort has been put forth to collect as many different varieties of banana offshoots as possible in order that they may be studied, and the rarer ones have been kept for further propagation. These bananas are being grown without irrigation, but the location is such that it is thought that the varieties will need only the natural rainfall for growth.

Apparently, some of the varieties that were formerly grown in these islands have disappeared. This is true particularly of the native varieties, the use of which depended largely upon certain characters of the fruit. There were probably about 30 such varieties of bananas in the Hawaiian Islands, but it is now difficult to secure offshoots of half that number.

While it is impossible to provide offshoots of different varieties to growers, it is hoped that distribution can soon be made to interested persons who are cooperating with the station in its endeavors to develop certain varieties for special use.

The second location is at the central station where a small planting of different varieties is being made. Irrigation is supplied this plat when necessary.

The bananas growing in the experimental fields are all varieties of *Musa sapientium*, except the Chinese banana, which is a variety of *M. cavendishii.*

PAPAYAS.

The papaya is rapidly becoming the recognized standard breakfast fruit of Hawaii, and demands for it are increasing as the population of the island increases. This popularity is due to its delicious and wholesome flavor and appetizing appearance. The demand for this fruit is also increasing on the mainland where there is a growing market for Hawaiian fruits. Local companies are utilizing the papaya by the ton, either in the preserved form, or as a jam combined with a by-product of the pineapple. It is also used as a relish and as dehydrated papaya. These uses are leading to the development of a new food industry which promises to become important. Such an industry calls for an abundance of fruit of uniform size and quality, and also for better and easier methods of propagating plants which will produce fruit of such characters. There are almost daily calls at the station for either seeds or plants of the papaya. During the year there were distributed from the propagation house over 5,000 papaya plants, a few of which were given to each person making application. These plants were large enough to be set in the garden. Many packages of papaya seed were also distributed.

The natural habits of the papaya are of such a nature that no true varieties having well-fixed characters can be fully established. This is due to the fact that it is propagated by seeds which are the product of insect pollination—one of nature's methods of getting variation in plants that are subject to cross-pollination.

Offshoots of papaya trees have been rooted as cuttings at the station and fruit-bearing papaya branches have been grafted on seedling stocks. (Pl. II, Figs. 1 and 2.) These methods have not, however, as yet been sufficiently worked out for use in propagating trees for Hawaiian groves.

Although the papaya is considered a tree that is easy to grow, problems frequently arise in connection with its propagation and complaints of failure often come to the station. These failures may be due to improper soil conditions, water supply, or unsolved fertilizer problems.

During the early part of the year new papaya plantings were planned and field work was begun. At present several varieties of papaya are growing on 2 acres of a new grove at the station. Plants 6 weeks old, which were set in the field on September 15, 1920, began to bloom on November 27, 1920, and now, June 30, 1921, they have fruit reaching maturity. The aim of the experiment is to develop a papaya tree that will conform as nearly as possible to the ideal and can be propagated on a large scale and be grown in all parts of the Hawaiian Islands. The ideal papaya should be one of vigor, having a single, straight, stout trunk tending to remain rather dwarfed. It should begin fruiting early and bear fruit near the ground. (Pl. III, Figs. 1 and 2.) The fruits should grow far enough apart to avoid deformity from crowding. The fruit should be uniform in shape, symmetry, and smoothness. It should ripen evenly, color before softening, and have good keeping qualities. The flesh should be a rich yellow or orange, and the flavor should be sweet, spicy, and highly palatable.

Most of the papaya plantings at the station were renewed this year from seeds of the varieties previously developed here. The old grove has been damaged by the weather and is considered unsatisfactory for further experimental purposes or for seed production.

MANGOES.

The mango work of the year was largely a continuation of that which was begun some years ago. The orchard, which numbers about 30 varieties of budded and seedling trees, was pruned and sprayed, and several hundred seedlings were propagated and set in nursery form for experiments in top-grafting the Pirie and several other choice varieties. Only a few varieties were in fruit in the fall of 1920, and specimens of the Brindabani, Smith-Wootten, and Mullgoa from the orchard were displayed in the station's exhibit at the Maui County Agricultural Fair from October 21 to 23, inclusive.

Unfortunately the mango orchard is set in shallow soil which is underlain by a rock layer to a depth of from 2 to 3 feet. This has caused the trees to develop their roots near the surface. The orchard can not be cultivated for these reasons and has suffered from drought during the past two summers. The combination of adverse conditions has rendered the orchard susceptible to insect attack.

CITRUS FRUITS.

In the citrus orchard at this station there are many varieties of citrus fruit trees. This orchard is in fairly good condition and nearly all of the trees are productive, notwithstanding the fact that they suffered greatly from drought during the past two summers.

From present indications it is thought that the best citrus fruits for culture in these islands are the Polynesian orange, the sweet shaddock, the Kusaie lime, and the Eureka lemon.

The Polynesian orange, sometimes called the Hawaiian orange or the Kona orange, is evidently one of distinctly Polynesian origin, as it was carried to many of the Pacific Islands by the Polynesian race. In 1792 it was brought into Hawaii from the island of Tahiti by Captain Vancouver. These oranges were the best on the local markets for a great many years, but they were gradually replaced by the highly colored, standard naval oranges from California. The Polynesian orange suffered from the ravages of the Mediterranean fruitfly, which almost caused its destruction. Now the reaction is in effect, and the Polynesian orange is again coming into its own. The fruitfly has been brought under control to a considerable extent by various parasites that have been introduced into the islands. The station will encourage the culture of this orange, which has had its good qualities by a long period of existence in a strictly tropical climate.

The station is also encouraging the culture and use of the Kusaie lime, which has been a popular fruit since its introduction in 1885 from the island of Kusaie in Micronesia (Pl. IV, Fig. 1). This fruit is a large, yellow lime, has few seeds, is smooth, and of excellent flavor. The trees reproduce fairly true to parent from seeds, are resistant to adverse conditions, and are prolific bearers, producing during almost the whole of the year.

The horticultural division has been fortunate in obtaining budwood from a sweet shaddock tree which is a prolific bearer of fruit having a very appetizing flavor. Bud selections are being made of the very best individuals of the three kinds of citrus mentioned above. These will be budded into sour orange, rough lemon, and pomelo

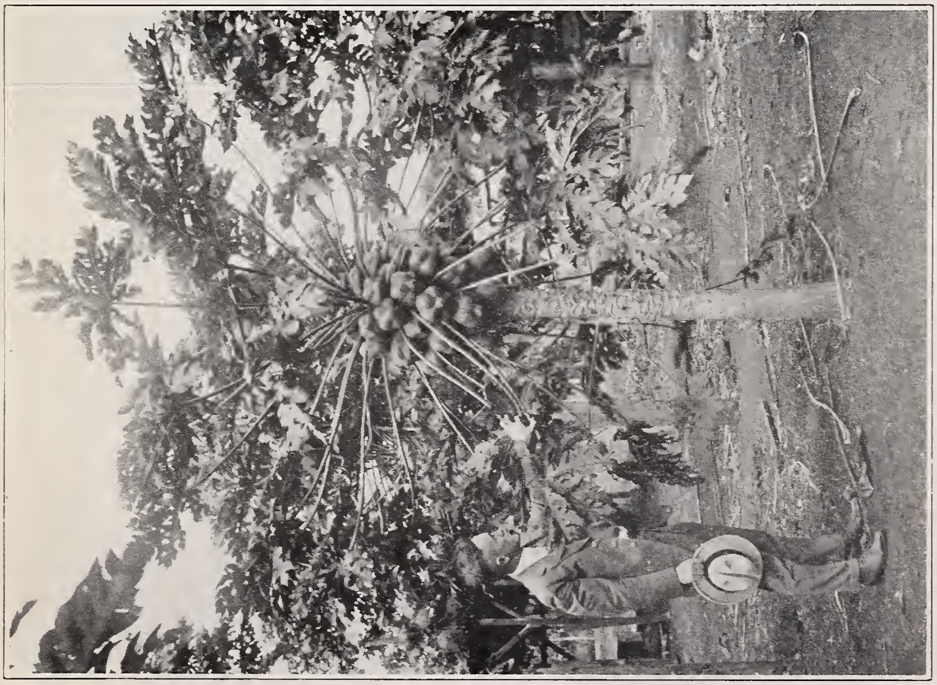

FIG. 1.—PAPAYA TREE, 17 MONTHS OLD. RIDGED TYPE OF FRUIT.

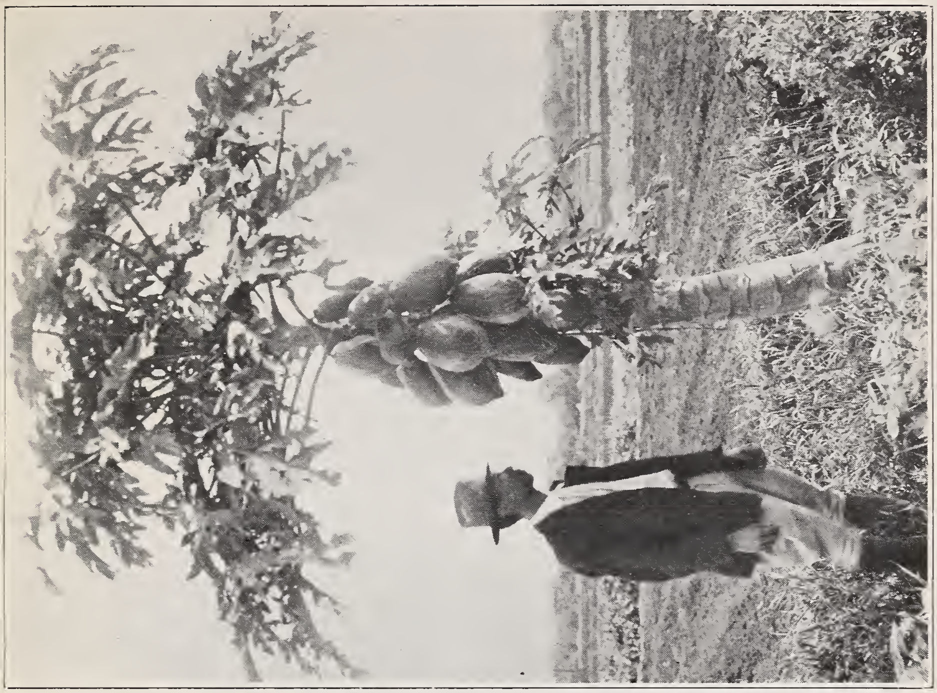

FIG. 2.—PAPAYA TREE, 2 YEARS OLD. SMOOTH TYPE OF FRUIT.

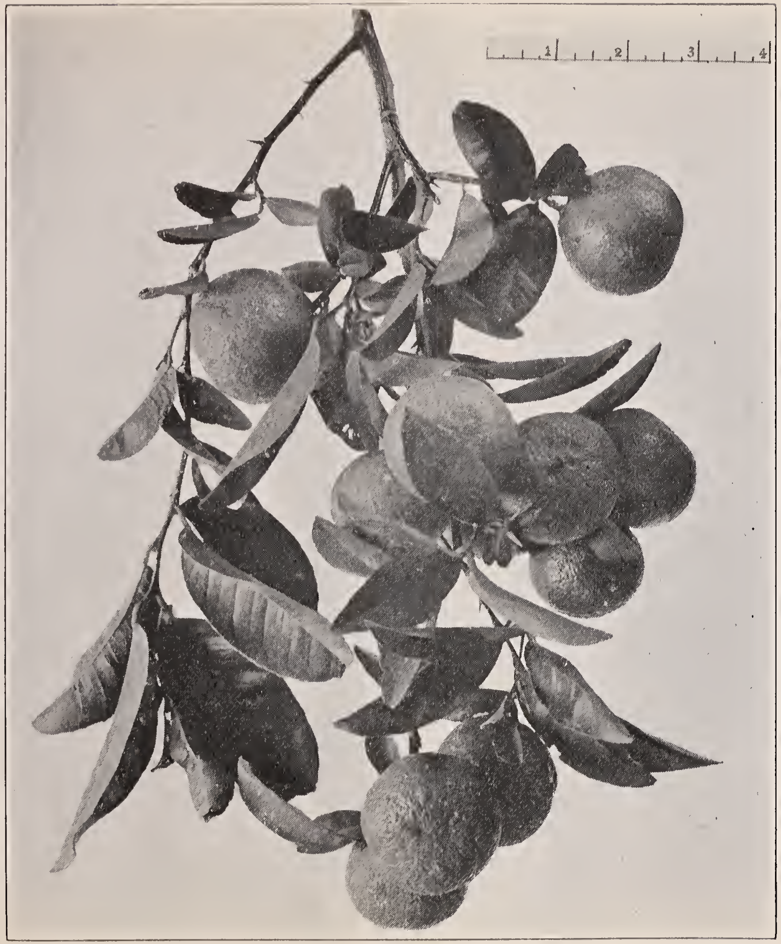

FIG. I.—KUSAIE LIMES OF EXCELLENT QUALITY. STATION GROUNDS.

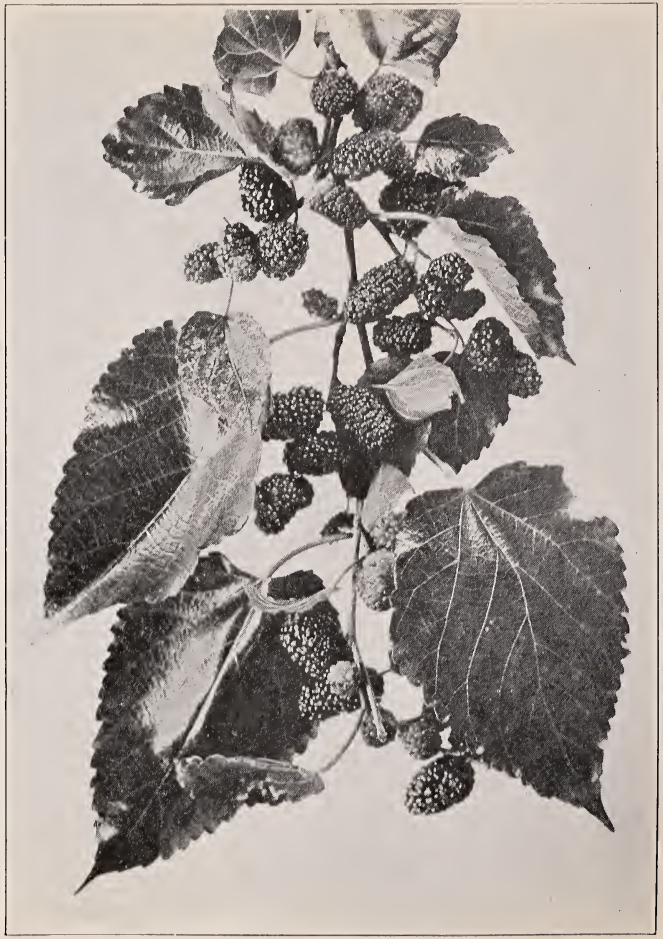

FIG. 2.—BLACK MULBERRY. ABUNDANT FRUIT FOR SEVERAL MONTHS IN EACH YEAR.

seedling stock, all of which have made vigorous growth in these islands. It is hoped that the three kinds of citrus can be established with standard qualities and that 2,000 trees of each kind can be propagated by the station for early distribution throughout the Territory (Pl. V, Fig. 1).

GRAPES.

During the year the Hawaii station started a new experimental vineyard with varieties of grapes from various parts of the world to determine their adaptability to Hawaiian climatic and soil conditions. The introduced varieties contain characters which it is thought will improve the grape industry in this Territory. The table and currant varieties received include the White and Black Corinthian, Isabella, Concord, Tropical American, Muscat, Thompson's Seedless, and Almeria.

Grape investigations were first undertaken by the station in 1902, when 50 varieties were introduced into Hawaii. Four years later a cooperative experiment was started on the island of Maui, where 177 varieties, mostly of the wine-grape type, were planted. No definite results were recorded of this planting. Among the first varieties introduced was the Isabella grape, which has been found best adapted to island conditions. During the past few years the station has been carrying on cooperative experimental plantings with private growers to improve the quality and yield of the fruit of the Isabella variety. This work has included methods of trellising, pruning, and the use of fertilizers. From one of these cooperative experiments propagating wood was obtained for starting the Isabella vines being used in the present experiment.

The station vineyard contains many vines of the Isabella grape. This variety seems to thrive in Hawaii, and the fruit can be found in the local markets during almost any month of the year. It is a variety that most amateur gardeners succeed in growing. In November, 1920, about 1,800 cuttings of this variety were rooted in sand and grown in pots to the proper size for planting in the open. All plants not used for the experiment were distributed later to those desiring them for their home gardens.

Two varieties of Corinthian grapes are being tried to determine the possibility of producing dried currants from them. Climatic conditions in certain areas of these islands are apparently suitable for the culture of these currant grapes. Their good characters have been well established by hundreds of years of cultivation in the mild climate of the Grecian Islands, and their culture for exportation in the dried form has long been a leading occupation of many people there. It is hoped that they can be successfully grown in Hawaii.

Muscat, a variety commonly found in California, where it was introduced, was selected for its fine qualities as a fresh fruit and for making raisins, but more especially for its distinctively peculiar flavor, which it is hoped will be transmitted in crossing. It is thought that a locality can be found in Hawaii where conditions will be suitable for the culture of this variety of grape. Thompson's Seedless is remarkable for its good table qualities. It develops well under irrigation in hot, dry localities. Almeria has remarkable keeping qualities and can be used to develop crosses for local culture. The old, reliable Concord has been grown in Hawaii to some extent, and while its fruit is somewhat like that of the Isabella, it has a more desirable flavor than that variety.

Plants of a tropical variety of grape, *Vitis tiliæfolia* (S. P. I. No. 44060), were sent to the station during the year by the Bureau of Plant Industry, United States Department of Agriculture, for crossing with other varieties in the hope of obtaining a hybrid that will be adapted to island conditions.

The objects of conducting experiments with grapes are (1) to determine the most desirable varieties for Hawaiian conditions; (2) to combine by hybridization characters that will give desirable varieties; (3) to combat the Japanese beetle (*Adoretus umbrosus*), which is a very destructive pest of foliage in certain localities; and (4) to determine the best methods of trellising, pruning, and of using fertilizers.

NUTS.

The nut investigations of the year were carried on principally with three species—the Macadamia, or Queensland, nut (*Macadamia ternifolia*), the pistachio nut (*Pistacia vera*), and the coconut (*Cocos nucifera*).

MACADAMIA.

The station has given considerable attention to the propagation of the Macadamia nut. This nut has grown rapidly in public favor since the trees of an early introduction came into bearing. The trees begin to bear at about 7 years of age, producing a crop for more than half the year, and the nuts are of very desirable quality (Pl. I, Fig. 2). The tree is also highly ornamental. Many young trees have been propagated during recent years from the nuts of a few large trees which are growing at the Tantalus substation. The greater number of these have been distributed throughout the islands, and the others have been set in grove form on the station grounds. Seedlings from several different varieties form a part of this collection, and it is hoped that improved types can eventually be selected from them.

The most desired change sought is a variety having a thin shell. Experiments in budding and grafting the Macadamia nut tree are also in progress. The Macadamia nut, described in a former report[5] of this station, is very desirable for growing in tropical and semitropical countries. It is highly nutritious, contains about 66 per cent fat, and has a pleasing flavor.

PISTACHIO.

The pistachio nut, which is being grown with great success in California and sold on the market for a good price, is popular on account of its rich flavor. It is also valuable for the green color it imparts when used in confections. The station obtained some budded trees through the Bureau of Plant Industry, United States Department of Agriculture, and also several pounds of the seeds of the hardy Chinese variety (*Pistacia chinensis*) for hardy stock, on which to bud the choice species of commerce (*P. vera*). A large number of these seedlings have been developed and will soon be ready for budding.

COCONUT.

During the year several tests were made with coconuts to determine the quickest and best way to secure germination. The nuts were buried in a pit of rice hulls in one test, and in a pit of black volcanic sand in a second test. Those which were buried in rice hulls required less time for germination than did the nuts that were buried in sand. Nuts having a small portion of the outer hull cut off at the base and planted with cut ends up germinated best of all. This method enables the small shoot to make straight growth without being retarded. The experiments showed that the coconuts germinate best when they contain the maximum amount of coconut milk. A number of nuts in which the coconut milk had dried failed to germinate when planted. Nuts in good, fresh condition, when set in rice hulls to a depth of 1 foot and kept well moistened, germinated and sent up shoots a foot high in three months. Nuts will germinate in black volcanic sand, but they dry out quickly, similar to the way they do in common soil.

LEGUMINOUS FRUIT TREES.

The station is giving some attention to the growing of four leguminous fruit trees in the hope of increasing their usefulness. The trees are the algaroba, the carob, the guama, and the tamarind, the fruits of which have only little true horticultural value in Hawaii. The algaroba and the carob are the most valuable of the four, owing to their use as feed for live stock. The guama tree was introduced mainly for its use as a shade tree in coffee growing. The tamarind is an introduced tree that is used principally as a shade tree in Hawaii. It has many uses in other tropical countries.

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[5] Hawaii Sta. Rpt. 1919, p. 17.

ALGAROBA (*Prosopis* spp.).

The horticultural division has from time to time received seeds of different species of Prosopis from various parts of the world. These seeds have been germinated and the plants placed in the field for trial. The local algaroba is a most valuable tree and has been fully discussed in a previous publication of this station.[6]

CAROB (*Ceratonia siliqua*).

The carob tree, the fruit of which is known as St. John's bread, is a leguminous tree which is grown extensively in the Mediterranean region for the large nutritious beans it produces. It was introduced into these islands at least 20 years ago, but is only occasionally found now. A new supply of the seed was obtained from California and planted during the year. It germinated well, and a number of trees were distributed to various parts of the Territory. The tree is ornamental, and the beans have a high food value when they are ground into meal for live stock. Many Europeans eat the sweet pulp which fills the pods surrounding the seeds. The carob tree will likely be a valuable acquisition to Hawaii when it is more extensively grown.

GUAMA (*Inga laurina*).

The guama tree is a tropical, leguminous species which is used to shade coffee trees. It is somewhat ornamental and produces one or two crops annually of bean-like seeds, the pods of which are large and plump. The seeds within the pods are surrounded by a mass of cottony-like pulp which is saturated with an edible sirup having a flavor like honey. The guama tree is not a great contestant for the available plant food in the soil. Guama trees are being distributed by the station.

TAMARIND (*Tamarindus indica*).

The tamarind tree was introduced into the Hawaiian Islands early in the nineteenth century, and while it is found growing in various parts of Hawaii, its many uses have not been developed here. The tamarind is a native of the Tropics of the Eastern Hemisphere. It is a medium-sized tree, having graceful acacialike foliage and hard, light-colored wood, which is used for making furniture. The tree bears annual crops of fruit, the pods of which are plump, from 3 to 6 inches long, and filled with a pleasant acidlike pulp surrounding the seeds. This pulp is used for several purposes, but principally for making a cooling beverage. The station plans to extend the cultivation of this tree in the hope of bringing it into more general use.

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[6] Hawaii Press Bul. No. 26.

MISCELLANEOUS FRUIT INVESTIGATIONS.

A study is now being made of certain miscellaneous fruits to determine their value, methods of propagation, and culture in Hawaii. It is thought that many of them will be brought into much more general culture when their real qualities and requirements are understood. The fruits include the star apple, breadfruit, black sapote, black mulberry, litchi, hybrid tomatoes, roselle, poha, and the annonas.

STAR APPLE (*Chrysosphyllum cainito*).

A number of star-apple trees have been propagated from seeds which were obtained from fruit trees growing on the station grounds. These young trees were soon distributed to many persons who are willing to try to grow them.

BREADFRUIT (*Artocarpus incisa*).

The breadfruit tree, the fruit of which was once extensively used for food by the Hawaiians, is now not generally grown. It is thought that its disuse is largely due to the difficulty with which the tree is propagated, and probably to the flavor of the fruit, for which a liking has to be acquired by many people. At present much interest is being manifested in the growing of the breadfruit tree. The fruit is seedless and the trees are usually propagated from root shoots which occasionally spring from surface roots of the parent tree. Very few root shoots could be obtained in the early part of the year. Surface roots were taken from trees which were known to have fruit of good quality. These roots, varying from one-half to 2½ inches in diameter, were made into cuttings about 1 foot in length, and the ends were smoothed with a sharp knife. These were placed in boxes of sea sand, a portion being set upright with about only an inch exposed and a portion being placed obliquely and at the same depth. A third planting was made by laying the cuttings horizontally several inches below the surface. All cuttings were kept moist and in a warm place. After about five months it was found that those laid horizontally below the surface had in part developed shoots and roots and were ready to be transplanted into pots. The cuttings which were set upright are still alive, but at this date (June 30, 1921), seven months after planting, they continue to show no sign of growth. The test will be continued until it is determined by what method root cuttings of the breadfruit tree can best be developed into plants.

BLACK SAPOTE (*Diospyros ebenaster*).

The black sapote, which is botanically related to the true persimmon, is the only representative of the genus Diospyros that was experimented with by the experiment station during the year. A few plants were germinated from seed which was obtained in these islands. Some were set in the station grounds, and the others were distributed. It is planned to make a further study of this peculiar fruit.

BLACK MULBERRY (*Morus nigra*).

A number of black mulberry trees have been growing at the station for several years. Many cuttings have been taken from these for rooting and distributing. Piece-root grafts were made, 90 per cent of which grew, and these have been distributed. The trees fruited for a period of about five months during the year. (Pl. IV, Fig. 2).

ANNONAS (*Annona* spp.).

The annona group includes a number of tropical fruit-producing plants of widely differing specific characters. Among them are many very excellent tropical fruits. The soursop (*Annona muricata*) and the common custard apple (*A. reticulata*) have been in cultivation for some years and have fruited this season. Another planting of different kinds was put out this year at the Tantalus substation, where it is believed that the 1,000-foot elevation will favor its growth. The following species are under test at the station: Cherimoya (*A. cherimola*), the ilama (*A. diversifolia*), soursop (*A. muricata*), the custard apple (*A. reticulata*), sweetsop (*A. squamosa*), and *A. atemoya*, supposed progeny of a cross between the cherimoya and the sweetsop.

LITCHI (*Nephelium litchi*).

The litchi is a very interesting and promising fruit, but it is rather difficult to grow successfully. The closely related species, the longan (*N. longana*), is being grown as a stock for the true litchi. The following varieties of the litchi (*N. litchi*) are under test at the station: Haak Ip, San Hing Heung Lai, T'in Naam, Saam Uet Hung, Waai Chi, Kwei Mei, and Longan. These varieties were obtained from China, the greater number of them being sent by the Canton Christian College. There is also an unidentified variety of *N. litchi* under test at the station.

HYBRID TOMATOES.

The work of developing hybrid tomatoes, resistant to the Mediterranean fruitfly, was continued during the year. Of the two types of hybrid tomatoes, the round and the oblong, the round type has been found the more satisfactory, and tomatoes approaching the original Earliana in size have been developed (Pl. V, Fig. 2). The demand for these tomatoes was again very gratifying and many packages of seeds and seedling plants were distributed. A specially promising strain of this hybrid was recently turned over to this division by the agronomy division, which was temporarily working with the crop.

ROSELLE (*Hibiscus sabdariffa*).

The roselle has been under test at this station for a number of years. The two varieties giving the most satisfaction are the Victor and the Rico, the latter of which is probably the better for Hawaiian conditions.

The roselle, being an annual, is propagated from seeds. A number of plants were distributed in season during the year. The roselle makes rapid growth, the seeds which are sown early in March, resulting in plants that are ready for transplanting to to the field by May, and the fruit being obtained in November and December. Considerable interest is being taken in the growing of this useful fruit for the making of jams, jellies, etc.

POHA (*Physalis* spp.).

The poha or Cape gooseberry (*Physalis peruviana*), also known as husk tomato or ground cherry, has been growing in Hawaii for many years. It is an introduced plant, but escaped from cultivation and is found growing wild at elevations of from 1,000 to 4,000 feet. The fruit is made into jams, jellies, used in pies, and is a favorite with many people.

Experiments with several kinds of pohalike fruits or husk tomatoes, including the purple giant hybrid, have been in progress, but all fruits produced to date have been found to be far inferior to the fruit of the wild poha. (*P. peruviana*). The experiment, however, will be continued next year with some of the varieties.

DISTRIBUTION OF SEEDS AND PLANTS.

The station has, by its frequent distribution of seeds and propagating materials to interested persons and institutions, been instrumental in extending the growing of improved varieties to all parts of the Territory. These distributions have created a general interest in new and improved economic plants, brought before the public the plants and shrubs that are useful as well as ornamental, and have resulted in the station receiving much valuable information concerning the possibilities of the plants' success in the particular localities where they were tried.

It is not the function of the station to send out seeds and plants of varieties that can be easily obtained from dealers. Seeds and extra plants that are not needed in the station experiments are distributed at regular hours, semiweekly, throughout the year. Distribution during the year included 125 mulberry trees (grafted), 292 watermelon plants, 5,293 papaya plants, 880 roselle plants, 4,532 tomato plants, 307 mango seedling trees, 12 fig trees, 432 Macadamia nut trees, 274 Kusaie limes, 83 star-apple trees, 117 guama trees, 145 carob trees, 64 granadilla plants, 1,645 hibiscus cuttings, 24 Pirie mango budwood slips, 32 panax cuttings, 32 croton cuttings, 6,234 poha plants, 150 Surinam cherry trees, and 793 grapevines, together with 173 packages of improved papaya seeds, and 53 packages of fly resistant hybrid tomato seeds.

SPRAYING EXPERIMENTS.

Insect pests were unusually troublesome in most parts of the Territory during the past year, owing to the very dry summer. The red spider and a troublesome mite were readily held in check by sulphur sprays which were applied to the affected citrus trees, mango trees, poha plants, etc. In the citrus and mango orchards of the station a spray composed of 50 gallons of water into which 1¾ pounds of whale-oil soap and 10 ounces of nicotin sulphate had been dissolved was successfully used. This spray was applied thoroughly with a spray pump as soon as insect attacks were discovered, and the application was repeated about every 10 days until three or four applications had been made.

The common mealybug attacked the maturing fruit of the late mangoes, but was easily brought under control by applying an oil spray made of 1 gallon of San-U-Zay oil and 30 gallons of water.

The mango weevil, which destroys the kernel of the seed of the mango, was very troublesome in some localities during the mango-fruiting season. All fallen mangoes were picked up and burned. This method was found very effective in the past.

The green caterpillar (*Plusia chalcites*), a foliage-eating insect which has been very destructive to many kinds of foliage, appeared in the spring of 1921 in various parts of the Territory. The remedy used for this pest was a spray composed of one-half ounce of arsenate of lead (paste form) combined with a gallon of water. This spray was also effective in reducing the attacks of the Japanese beetle.

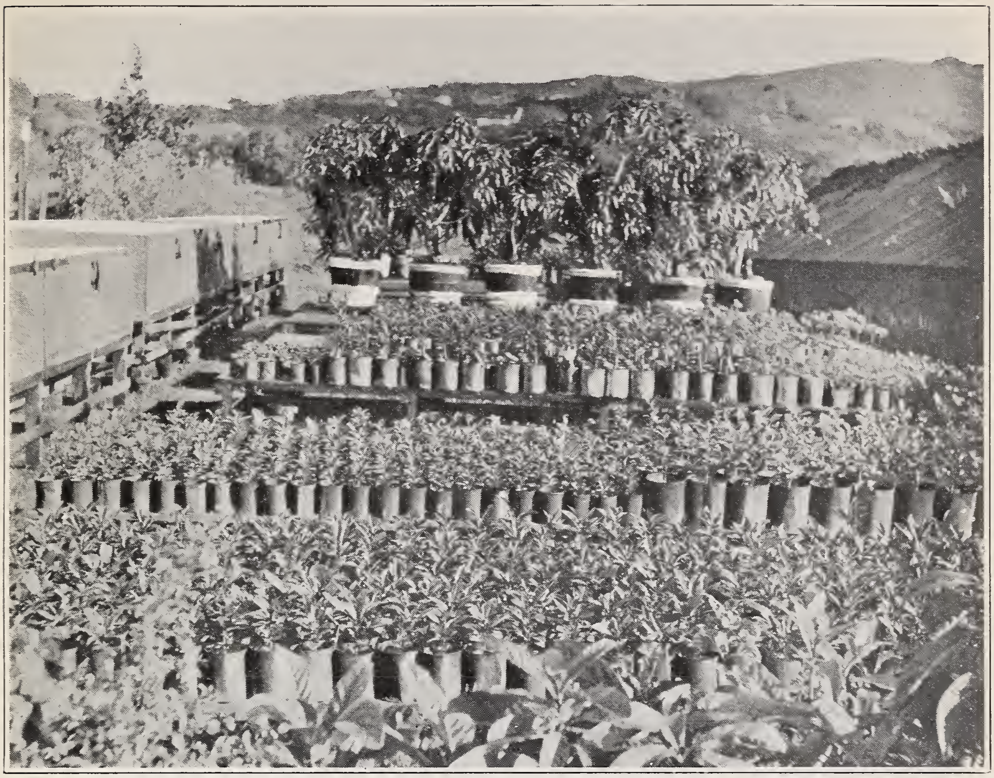

FIG. 1.—GROWING CITRUS STOCK ON WHICH TO GRAFT SWEET SHADDOCK AND HAWAIIAN ORANGES.

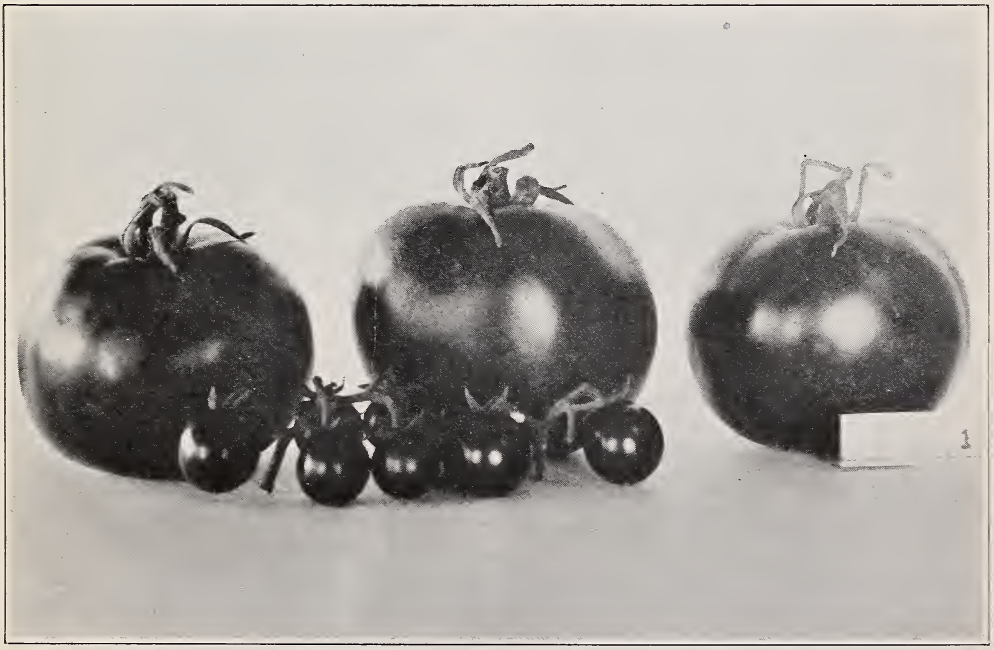

FIG. 2.—HAWAII HYBRID TOMATO. RESULT OF CROSSING EARLIANA WITH POLLEN OF SMALL WILD VARIETY, FRUIT OF WHICH IS SHOWN IN FOREGROUND.

The Mediterranean fruitfly has done much damage in the past to citrus fruits and tomatoes, as well as to other fruits, but destruction has been considerably reduced, apparently by parasitic enemies which have been introduced into Hawaii.

SPECIAL PROPAGATION INVESTIGATIONS.

One of the greatest problems of the plant propagator is how to grow successfully certain plants by methods other than that of planting seeds. The most natural method of propagating plants seems to be by seed, but seed, often the result of cross-fertilization, produces variation. By this method many kinds, or variations of kind, of plants are produced, some of which may show improvement over the parent plant. Many plants reproduce themselves asexually: that is, individuals of the same kind spring up from rooted runners, layers, or separated pieces. Man has extended this asexual process by budding, grafting, and inarching trees and plants, and by planting cuttings. By means of some one of these methods there are now propagated many plants which formerly grew from seed alone. The object of asexual propagation is to avoid variation, and a good variety thus obtained can be retained and handed down through many so-called generations of individuals. There are many plants, however, which do not reproduce easily by these methods and many that have not as yet been so propagated. Carefully worked out methods, however, occasionally show the way in which plants that have never been reproduced asexually may be so produced, and how those which have been so propagated with difficulty may be propagated easily. For example, avocados, mangoes, Bougainvilleas, and others were formerly difficult to root from cuttings or to grow from buds or grafts. Improved methods employed under certain conditions have met with success, and such plants are now considered comparatively easy to propagate.

The station has endeavored to extend into large plantings good varietal characters in the litchi and the papaya, but no methods of asexual propagation have as yet been developed on a practical scale in Hawaii.

The horticultural division is starting an experiment in propagation by means of a "sweat box," which was designed by the Office of Foreign Seed and Plant Introduction, Bureau of Plant Industry, United States Department of Agriculture. This box consists of a strong framework of redwood with sides, ends, and top filled in with double-strength panes of glass. The outside of the box measures 29 inches in width, 32 inches in height, and 42 inches in length. A galvanized-iron pan, which is 2 inches deep and large enough to fit fairly snugly inside, is supported at about 8 inches above the bottom. On top of the pan are stiff cross-braces of galvanized iron. These hold up galvanized-wire netting of one-half inch mesh, which supports a layer of spaghnum moss over the surface to 2 inches in depth. A high uniform temperature is maintained in the pan by a small electric heater which is placed directly under it, and the water is driven off slowly, causing considerable humidity in the box. The cuttings are placed in some suitable medium, varying in the different experiments, and rest upon the moist spaghnum moss.

REPORT OF THE AGRONOMY DIVISION.

By H. L. Chung.

INTRODUCTION.

The agronomy division again devoted its energies to the production and improvement of food crops for man and forage crops for animals, and to the distribution of propagating material of improved crops. Many activities of a cooperative, demonstrative, and advisory nature were undertaken during the year, including the rejuvenation of old alfalfa fields, the selection of grasses that are best adapted to particular localities, the making of plans for diversified farming, and the solution of problems connected with the poultry industry.

ROOT CROPS.

CASSAVA.

The work with cassava for the year was confined to the propagation of all varieties now growing in the agronomy field in connection with a varietal test. It has been found impossible to grow a satisfactory crop of cassava on the heavy type of soil assigned to it at the station unless the land is given an undue amount of cultivation. For this reason the agronomy division will henceforth grow this root crop principally in cooperation with persons who are interested in it and who have available labor and land that is suitable for the growing of cassava.

EDIBLE CANNA.

During the year the edible canna investigations constituted one of the main subprojects of the division. There has been a great difference of opinion as to the time edible canna corms should be harvested to secure the maximum amount of starch. To determine this a large area was planted in edible canna that was harvested each month beginning with the fourth month after growth. The corms were washed and dried, the starch was extracted from them, and the quantity of water, fiber, and starch was determined. This investigation was carried on in cooperation with the chemical division of the station. Samples of the corms which were harvested each month were submitted to the chemist for analysis.

SWEET POTATOES.

Sweet-potato investigations were confined largely to two cooperative varietal tests with two ranchers having soils of a similar nature but located about 46 miles apart. In addition, a plat in the agronomy field was planted with several promising varieties which were to be used as propagating material for general distribution.

The first cooperative sweet-potato variety test was carried out on the Kahuku ranch, at Kahuku, Oahu. This land, about 1 acre in size, has very sandy soil and is only a short distance from the ocean. Seven varieties of sweet potatoes were planted 2 feet apart in rows that were spaced 4 feet apart. Every vine made luxuriant growth as the result of the field having been kept sufficiently moist by a modified Skinner system of irrigation. After six months' growth the sweet-potato crop was harvested. About a dozen plants only had developed normal sweet potatoes. The others had well developed, but only slightly enlarged, roots radiating in all directions. The cause of this nonproductiveness was probably due to the new soil condition to which the plants were subjected. It was suggested that the above sweet-potato field be grazed by cattle and later sowed to Australian saltbush (*Atriplex semibaccata.*)

The second sweet-potato experiment was conducted in cooperation with the Kuliouou ranch, island of Oahu. The soil conditions and the results obtained were similar to those of the Kahuku field. Eight varieties of sweet potatoes were planted on March 23, 1920, on half an acre of land on which watermelons had previously been grown. The planting was made in rows 4 feet apart, and the plants were spaced 2 feet apart in the row. Owing to the meager rainfall and the lack of irrigation, the stand was rather poor. The best stand was made by station variety No. 111, of which 60 per cent of the cuttings were established. The poorest stand was made by station variety No. 58, of which only 20 per cent of the cuttings grew. The crop was harvested on September 22, 1920, when each variety bore a few tubers only. Practically all of the vines showed abnormal growth and a decided absence of chlorophyll, the leaves being yellowish to light cream in color. An appreciable amount of salt was detected when the tubers were tested by tasting. Samples were brought to the laboratory for determination of the salt content. Potatoes that grew nearest to the seashore had a slightly higher salt content than those that grew in other parts of the field. The results of the analysis of the sweet potatoes for their salt content is given in the following table:

Salt content of sweet potatoes produced at various distances from the seashore.

Hawaii station number.	Location of vines.	Water in fresh potato.	Sodium chlorid.	
			In fresh potato.	In oven-dried potato.
		Per cent.	*Per cent.*	*Per cent.*
56	About 100 feet from seashore	73.9	0.594	2.27
56	Middle of the field	70.3	.580	1.95
56	About 335 feet from seashore	69.3	.666	2.18
111	About 100 feet from seashore	78.3	.571	2.63
111	Middle of the field	71.2	.703	2.44
111	About 335 feet from seashore	70.0	.694	2.31
3874	About 100 feet from seashore	74.7	.726	2.37
3871	do	77.2	.483	2.12

IRISH POTATO.

Periodic tests were made with the Hamakua Hybrid potato, a variety which had its origin on the island of Hawaii, and which seems to be blight resistant. All tests have revealed the fact that a fairly large crop of merchantable tubers can be produced from stocks that are obtained from the place of their origin, even when no spray is used. Succeeding generations of this variety, however, when grown on the island of Oahu, do not seem to retain their blight-resistant characters. An attempt is being made to develop by selection a strain of this potato which will be blight resistant under all conditions.

TARO.

The taro investigations, especially the variety and fertilizer experiments, were unavoidably delayed by the scarcity of labor for such work and by a rainstorm which partly destroyed the taro dikes. The damaged fields have been repaired and fertilizers have been applied. The harvesting period will begin about November 1, 1921.

The taro crop investigations are considered important and every effort will be made to carry on the work thoroughly during the coming year and thereafter to increase the yield by varietal selection and fertilizing. That there is need of special attention being given to this root crop in Hawaii is evident. The total taro acreage under cultivation by individual native Hawaiians is rapidly diminishing. The taro lands are being abandoned, allowed to lie fallow, or sold for home sites, and as a result only a few people now own taro patches. This has given rise to a deplorable situation, since the few people who own taro lands have absolute control of the price of taro and poi, its product.

CORN.

The corn investigations were confined largely to breeding and selection work. The yellow strain of Guam corn,[7] which this station has been striving to establish, occupied 1 acre at the station and 10 acres elsewhere on the island of Oahu during the year. The work included stabilizing the strain as to color and type of kernels, and increasing the length of the ear by intensive selection. Long and well-filled ears having all yellow kernels and conforming to the characteristics of the original white variety were selected direct from the field and taken to the laboratory for reselection and recording. They were then planted in the field for further selection work.

At the Love ranch, a short distance from Honolulu, about 6 acres were planted in the yellow Guam corn in January, 1921. Matured ears 9½ inches long were commonly found in the field. Such ears were selected for future planting.

A comparative test was made during the year to determine the yield of four varieties of corn for green fodder. The results are given in the following table:

Yield of green fodder from four varieties of corn.[1]

Variety.	Height of stalks.		Yield of fodder per plat.[2]	Calculated yield per acre.
	Maximum.	Average.		
	Feet.	*Feet.*	*Pounds.*	*Tons.*
Guam (white)	9.5	8.5	2,440.0	26.7
Guam (yellow)	9.0	8.0	2,187.5	25.8
Cuban Red	10.0	8.5	2,337.5	27.5
Cuban Red×Guam	10.0	8.5	2,640.0	31.0

[1] Cut 60 days after planting.
[2] The area of each plat was 1,840 square feet.

In addition to the work with the Guam variety, tests were made with a number of varieties which were received from different sources during the year. The sweet varieties (station Nos. 1398, 1399, and 1400), which were donated by Mrs. Shorely, a visiting tourist from New York, failed to develop normally, owing to the ravages of the corn-leaf hopper (*Peregrinis maidis*) and difference of climatic conditions. E. M. Ehrhorn, chief inspector of plants of Hawaii, also donated three varieties (station Nos. 1427, 1428, and 1429) which he obtained from Bolivia. The variety Cuzco (No. 1427) belongs to the *Zea amylacea* type, the kernels being large and soft, and measuring thirteen-sixteenths of an inch long by three-fourths of an inch wide. The other two varieties were members of the flint type. These three varieties were planted and grew to a height of about 10 inches.

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[7] Hawaii Sta. Rpt. 1919, p. 44.

Then they gradually withered and died, although no corn-leaf hoppers were to be found on the stalks.

R. P. Bainbridge, of New York, who also visited the station during the year, and who includes sweet corn among his garden hobbies, donated to the station three varieties, Pocahontas Early, Henderson Sweet, and Golden Bantam, which have made remarkable growth. This is the first time that a sweet variety has been grown at the station with any reasonable degree of success. Seeds will be selected from these varieties for future plantings.

NONLEGUMINOUS FORAGE CROPS.

NAPIER AND MERKER GRASSES.

During the year propagating material of Napier or elephant grass (*Pennisetum purpureum*) and Merker grass (*P. merkeri*) was distributed in large amounts to dairymen and to poultrymen throughout the Territory. The station distributed 28,000 more cuttings of these two grasses this year than in 1920.

In connection with the propagation of these two grasses, a study was made of their morphology, habits of growth, and possibilities when they are subjected to various conditions.

UBA CANE.

Uba, or Japanese, cane, which has been growing continuously on the same ground on which it was planted July 17, 1915, bloomed for the first time on December 12, 1920, after its seventh cutting. Five stalks growing in the northwest corner of the field bloomed normally, while 23 other stalks from the same location bore diseased and abnormal tassels. These diseased floral parts developed to a certain stage and then began to decay from within, the decay starting apparently at the floral axis. During the year 4,500 cuttings of Uba cane were distributed.

LEGUMINOUS FORAGE CROPS.

ALFALFA.

A demonstration plat containing different varieties and strains of alfalfa has been started in the agronomy division. In another field a plat of the Peruvian variety was maintained during the year to furnish sufficient seed for distribution in small amounts. In addition to the distribution of the alfalfa seed, 150 pounds of soil for inoculation experiments was sent out in lots varying from a few ounces to 50 pounds.

COWPEAS.

Twenty-one varieties of cowpeas, which were received from the Bureau of Plant Industry, United States Department of Agriculture, were planted on February 3, 1921, between rows of pineapples, which were spaced 4 feet apart. These varieties were grown in a comparative test with varieties that have been growing at the station for some years, the purpose being to determine their relative merits for use as green manure. The following datá were obtained when the plants had made two months' growth.

Forage yield of cowpea varieties grown in comparative test.

Station No.	Variety.	Yield of green forage per plat.	Calculated yield per plat.	Station No.	Variety.	Yield of green forage per plat.	Calculated yield per acre.
		Lbs.	*Tons.*			*Lbs.*	*Tons.*
1431	Grout	1.75	0.473	1446	Columbia	6.25	1.69
1432	Large Blackeye	3	.81	1447	Early Buff	9.25	2.5
1433	Couch	7.5	2.03	1448	Early Red	12.5	3.38
1434	Iron	9	2.4	1449	Early Ramshorn	6	1.62
1435	California Blackeye	5	1.3	1450	Sugar Crowder	9.5	2.57
1436	Victor	4	1.08	1451	New Era	18	4.8
1437	Brown Crowder	8	2.16	1412[1]	Black Select	16.75	4.53
1438	Taylor	5	1.3	872 A	Red Ripper	17.5	4.73
1439	Potomac	12	3.24	1383 A	Station Hybrid	16	4.32
1440	Arlington	2.5	.67	1411	Station Selection	16.5	4.96
1441	Black	6.5	1.76	872 B	Red Ripper	10.5	2.84
1442	Native Blackeye	7	1.89	1383 B	Station Hybrid	14.5	3.78
1443	Extra Early Blackeye	4.5	1.21	1410	Selection No. 1410	11.5	3.11
1444	Buff Catjang	5.75	1.55	877	Taylor	11.5	3.11
1445	Asparagus	8	2.16	1192	Whippoorwill	21	5.6

[1] The last 9 named varieties or selections have been growing at the station for more than 2 years.

KULTHI BEAN.

A 20-foot row of kulthi beans (*Dolichos biflorus*) was planted adjacent to the cowpea plat. The plants were still green after they had produced 2 pounds of matured seeds. The green forage when cut weighed 10 pounds, which production was at the rate of 2.7 tons of green forage per acre. The acre yield of the seeds was 1,089 pounds.

MUNGO BEAN.

A comparative test with the green and yellow mungo beans (*Phaseolus mungo*) showed that the latter variety is far superior to the former in the production of forage. The green variety produced only 77.5 pounds of green matter (1.6 tons per acre) compared with 190 pounds (4.1 tons per acre) produced by the yellow variety. Owing to the fact that the crop was injured by birds, no weight was taken.

LUPINE.

A cultural test was made of a lupine (*Lupinus albus*) that was obtained from the Haiku substation. As a crop for green manure, this variety of lupine yielded at the rate of 4.87 tons per acre, the actual yield being 237.5 pounds from a plat 20 by 50 feet.

KUDZU.

Interest in the kudzu vine (*Pueraria thunbergiana*) has been stimulated by various American and European agricultural periodicals during the past two years, and as a result some of the local people, who are interested in this promising legume, have made numerous requests of the station for propagating material. The plat of kudzu in the agronomy field was too small to supply the necessary cuttings, so seeds were planted in other plats, and later plants were distributed to the public.

Observations were made of the growth of the kudzu plants which were grown from cuttings and seeds to determine the relative merits of each. Accordingly, cuttings made from matured vines were planted in plats containing sandy soil. Kudzu seeds were planted at the same time, and under the same conditions. Four weeks later the resulting plants were set in the field. The transplanting apparently was not detrimental to any of the plants, since they all grew. Later, however, observations showed that the plants which were grown from seeds were making only little progress, while those grown from cuttings made rapid progress and sent forth their long, pubescent vines in all directions. Twelve months after transplanting there were harvested 10 hills of kudzu plants from cuttings and from seeds. Every plant that grew from cuttings bore one or more enlarged roots, while the plants that were grown from seeds had elongated fleshy roots only (Pl. VI, Fig. 1), although the growth of the foliage of the two was about equal.

In addition to the above-mentioned work on kudzu, samples of hay, meal, crude and refined starch, and fiber were made from the kudzu plant for exhibition purposes.

THE YAM BEAN.

The yam bean (*Pachyrrhizus tuberosus*) is a legume that is little known to American or European agriculture. It is cultivated by the farmers of the Orient for its fleshy and edible roots. (Pl. VII, Figs. 1 and 2). Fifty seeds were obtained from a local vegetable grower and planted in field N. No attempt was made to determine the yield of the root crop, because the planting was made primarily to obtain a supply of seeds for sowing a larger area for the purpose of studying the growth, habits, and yield possibilities of the plant.

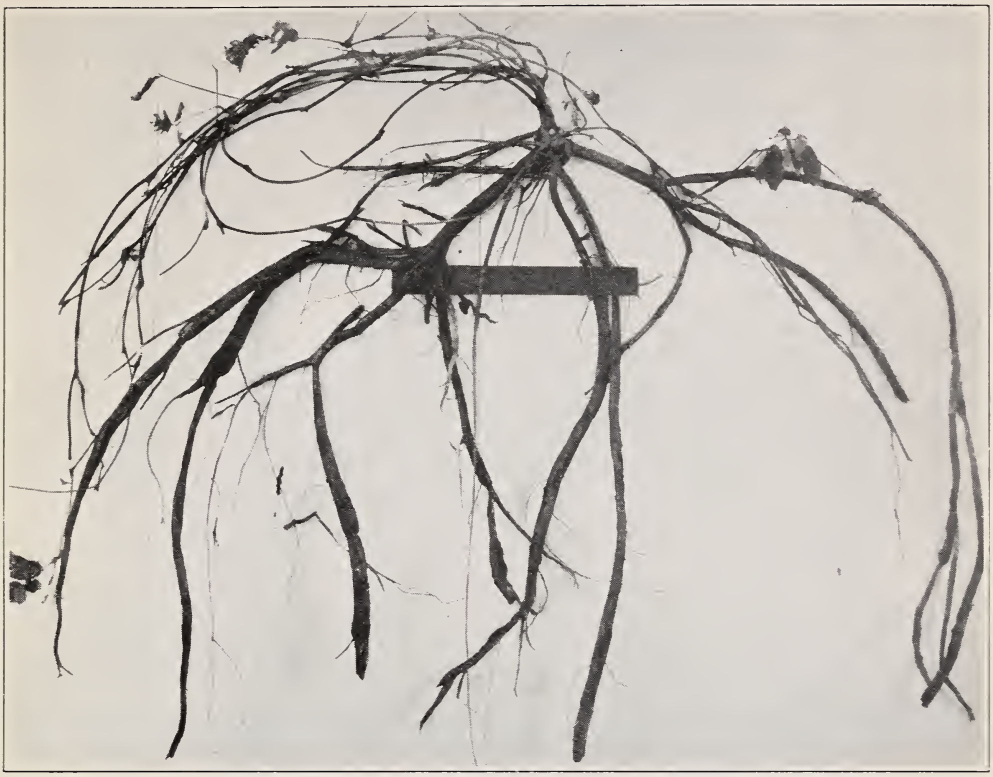

FIG. I.—PLANT OF KUDZU 7 MONTHS FROM SEED, SHOWING HEAVY, FLESHY ROOT SYSTEM.

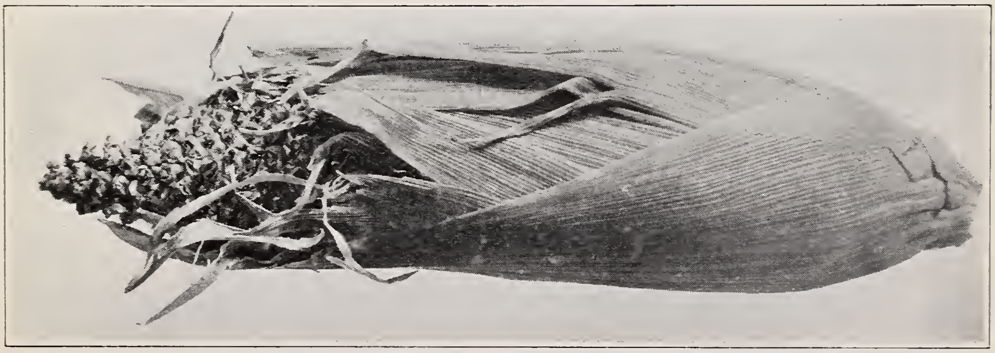

FIG. 2.—EAR OF CORN DAMAGED BY ENGLISH SPARROWS.

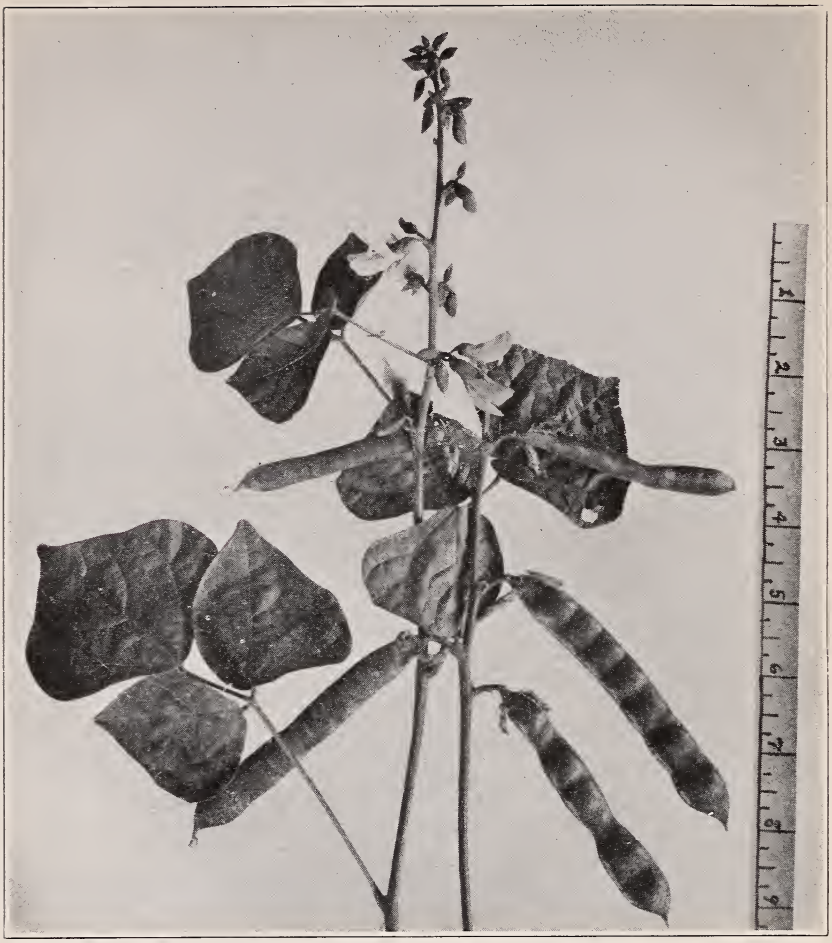

Fig. 1.—Foliage, flowers, and pods of Yam bean (Pachyrrhizus tuberosus).

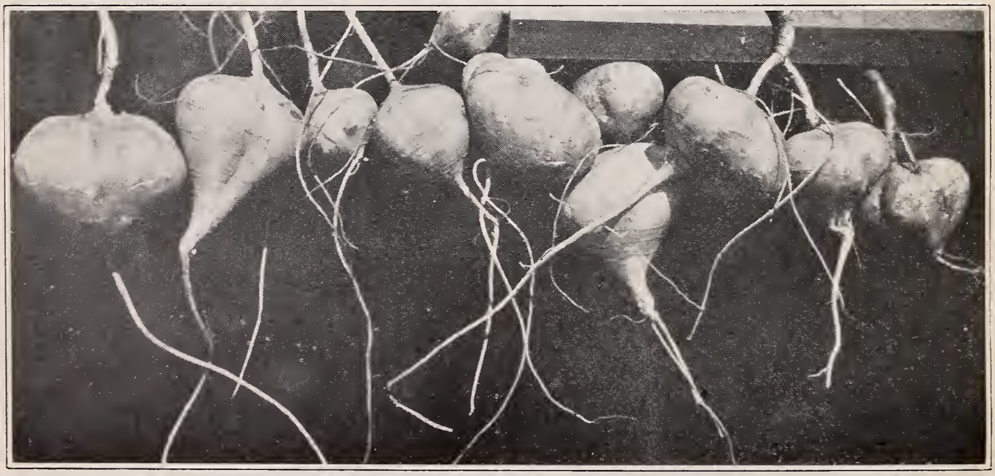

Fig. 2.—Roots of Yam bean; extensively grown by Orientals as a favorite vegetable.

PEANUTS.

No experimental work was undertaken with peanuts during the year. This legume was used extensively, however, for crop rotation, and incidently to replenish the seed supply for distribution.

MISCELLANEOUS CROPS.

CABBAGE.

A comprehensive fertilizer experiment was begun by the agronomy division to determine the fertilizer that is best suited for three varieties of Chinese cabbage. The planting was made on December 8, 1920, and the fertilizers were applied 20 days later. A rainstorm occurred in January and destroyed the entire experimental planting of cabbage. Between January 1 and 21, 1921, a total of 14.3 inches of rain fell. A second planting was then made with the seeds that were on hand. The result of the test will be reported in the next annual report.

TOMATO.

The agronomist did some tomato-breeding work in a private capacity at his home, using the Cowan hybrids[8] as foundation stock. A continuous selection and breeding experiment with a limited number of plants gave a prolific tomato plant which reproduced itself with fruits larger than the original Cowan cross. The tomatoes show a remarkable degree of resistance to the attacks of the melon fly (*Bactrocera cucurbitæ*) if the large number of ripe and uninjured fruits obtained can be taken as an indication of their fly-resistant character.

Seeds of this particular tomato plant were saved and turned over to the agronomy division on December 1, 1919, so that proper methods of increasing and improving the variety could be followed. A small plat in the agronomy field was planted to this tomato selection, together with a number of standard varieties for crossing. Three hundred successful crosses were secured and the hybridized seeds were turned over to the horticultural division, where the work of improving a fly-resistant variety with large fruits will be continued.

ENEMIES.

BIRDS.

The English sparrow (*Passer domesticus*) was a serious pest of the bean and corn crops at the station during the year. The bean crop, while still in its green stage, was shelled by these birds, and an accurate yield of the seed crop could not therefore be obtained. The ears of corn were damaged by the birds, which removed the green shucks at the tip to gain access to the kernels. After sufficient moisture had gathered about the damaged parts the ears decayed. (Pl. VI, Fig. 2.)

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[8] Hawaii Sta. Rpt. 1918, p. 19.

The English sparrow is a very destructive pest to food crops in Hawaii, and unless its rapid reproduction is curbed the growing of beans and similar crops will be greatly handicapped.

The rice birds (*Munia nisoria*) also did considerable damage in the agronomy field. On one-tenth acre planted to three varieties of Chinese cabbage for seed production, these birds have commenced to shell the green seed pods for the matured seed.

INSECT PESTS.

Corn-leaf hoppers (*Peregrinis maidis*) appeared in large numbers as usual in the agronomy field where corn was growing, but their damage was negligible so far as the Cuban Red and Guam varieties were concerned. The other new varieties of corn were severely damaged, however, the entire crop being ruined.

The common cabbage worm (*Pontia rapæ*) damaged the cabbage fields to some extent by devouring the tender leaves. This pest was parasitized by *Frontina archippivora*, which helped to destroy most of the larvæ. Many parasitized individuals were found on the under surface of the cabbage leaves.

The presence in great numbers of weevils (*Bruchus chinensis* and *Calandra oryzæ*) have made it necessary to fumigate the corn and bean seed monthly.

The cane-leaf hopper (*Perkinsiella saccharicida*) was observed on the Uba cane at this station for the first time on December 12, 1920. Only a few of these pests were found, and they soon disappeared. Examination of the cane leaves showed the presence of many eggs. No nymphs, however, have been observed as yet.

POULTRY.

During the World War the citizens of Hawaii were urged by the national and Territorial agencies to produce as much vegetable and animal food as possible. In response many undertook gardening in their back yards, and others combined poultry raising with vegetable gardening. These war-time measures were not abandoned with the cessation of hostilities, and many who had acquired an interest in the work decided to continue it; others were obliged to do so on account of the high price of vegetable and poultry products. Many interested but inexperienced poultry keepers who were successful during the first and second years of their undertaking called on the agronomy division for assistance when their flocks became affected with various kinds of disease. Although the energies of the agronomy division are largely devoted to work with farm crops, a portion of it was given to pressing poultry problems needing solution. In no instance, however, did the time given to poultry work jeopardize the agronomic work.

Timely illustrated articles dealing with the poultry industry were frequently prepared by the agronomy division for publication in one of the local daily newspapers. The articles conveyed useful information, applicable to Hawaiian conditions, to poultrymen in the Territory.

Caponizing is one phase of the poultry industry in which the local poultrymen are very much interested. The capon is in great demand during the holiday festival season, which is observed by the Chinese in Hawaii, and it sells for $1.25 per pound. At this price, a fowl of the American class weighing 12 pounds will net an exceptionally good return. The local market, however, prefers birds weighing not more than half that weight.

During the year the agronomist's attention was called to two diseases that were affecting the poultry of the island. In one disease the glandular stomach of young fowls became abnormally enlarged as a result of being heavily infested with round worms (*Dispharagus nasutus*). Eighty-eight large and small worms were found in the stomach of one fowl. The cause of the other disease has not as yet been determined. A six-weeks old Black Minorca chick, which was the third victim of this disease, was apparently normal in the morning, but commenced to stagger about noon, and died before night. A post-mortem examination showed no sign of external or internal injury to the body, and the respiratory organs and digestive tract were found to be normal other than for the two cæca, which were filled with coagulated blood.

Although the poultry industry in Hawaii is still in its embryonic stage, it promises to make rapid development, and it is hoped that means will be found to enable it to become established on a profitable basis. The station expects to continue to assist and encourage local poultry and egg production in every way possible. It is hoped that a strain of fowls best adapted for egg production under local conditions can be developed within the next year or two, and that egg-laying contests can be held to stimulate interest in the poultry industry.

REPORT OF THE CHEMICAL DIVISION.

By J. C. Ripperton.

INTRODUCTION.

The major part of the work of the chemical division for the year was devoted to the cooperative experiments which were started during the previous year, and to making analyses of soils, fruits, root crops, starch, and starch residues.

COOPERATIVE FERTILIZER EXPERIMENTS.

PINEAPPLES.

The first crop of pineapples in the fertilizer experiments was harvested on June 30, 1921. The whole field had made exceptionally vigorous growth. Half of every plat was given a small supplementary application of fertilizer when the plants were in the flowering stage, at which time they are most inclined to collapse. Wilt is already beginning to appear throughout the fields.

BANANAS.

An unusually severe windstorm uprooted almost the whole banana field before half of this year's crop was harvested. The stalks which had fallen were cut so that the new offsets or suckers would have a better chance to develop. No very pronounced effects of the fertilizer treatment could be observed. The experiment will be continued with the next crop.

UPLAND SUGAR CANE.

During the summer of 1920 the drought was so severe that upland sugar cane made very slow growth. The cane is now making vigorous growth, but it will not be ready for cutting until the autumn of 1921.

FERTILITY-ROTATION EXPERIMENT.

This experiment is planned to provide short rotations for pineapples and sugar cane, and at the same time maintain soil fertility by plowing under pigeon peas as a green-manuring crop. During the year one pigeon-pea crop was harvested and the succeeding crop was plowed under. The plan is to harvest one crop and turn under the next crop each year. The first harvest of pineapples is under way (June 30, 1921). The sugar-cane crop will not be cut until the fall of 1921.

PINEAPPLE-WILT EXPERIMENT.

The pineapple-wilt investigations were abandoned after the first crop of pineapples was harvested, the station deeming it advisable to withdraw from the field because of the extensive experiments that were being undertaken by a local association.

From the standpoint of the "wilt," the experiment gave no positive results. The disease was equally as severe on the treated as on the untreated plats. On plats Nos. 1 and 23 the spray was so concentrated that the tops of all the plants were burned. The wilt has attacked the new growth with as much vigor as it has the old growth. Pineapple growers agree that chemical sprays are of little or no avail in checking the disease. Where they were used, small increases in weight of fruit and decreases in No. 2 fruit were apparent. Slight gains were made when acid phosphate and ammonium sulphate were applied to the plats. The results of the first harvest are given in the following table:

Results of applying certain disinfectants and fertilizers to the first crop of pineapples affected with wilt.[1]

[Unless otherwise stated, the following concentrations of solutions were used: Copper sulphate, 1-1,000; ammonium sulphate, 1-16; acid phosphate, 1-40; and potassium sulphate, 1-80.]

Number of plat.	Treatment applied to plants.	Number of fruits picked.		Average weight per fruit.
		No. 1.	No. 2.	
				Pounds.
1	Copper sulphate (1-100); tops[2]	22	1	4.20
2	Copper sulphate; tops	214	12	4.53
	Check plat	221	19	4.40
3	Copper sulphate; roots[3]	215	18	4.40
4	Copper sulphate (1-10,000); tops	188	12	4.63
	Check plat	192	16	4.54
5	Ammonium sulphate; tops	180	17	4.51
6	Ammonium sulphate and copper sulphate; tops	179	14	4.43
	Check plat	170	34	4.31
7	Ammonium sulphate; roots	161	7	4.64
8	Ammonium sulphate and copper sulphate; roots	219	14	4.64
	Check plat	183	19	4.37
9	Copper sulphate (1-10,000); tops	161	27	4.16
10	Copper sulphate (1-10,000); roots	172	23	4.52
	Check plat	178	29	4.33
11	Bordeaux mixture (1-1-10); tops	180	17	4.36
12	Bordeaux mixture (1-1-10); roots	183	34	4.21
	Check plat	134	21	4.24
13	Acid phosphate; tops	115	12	4.46
14	Acid phosphate; roots	129	16	4.64
	Check plat	165	16	4.27
15	Acid phosphate and copper sulphate; tops	58	10	4.21
16	Acid phosphate and copper sulphate; roots	133	16	4.38
	Check plat	141	21	4.23
17	Acid phosphate and ammonium sulphate; tops	124	10	4.36
18	Acid phosphate and ammonium sulphate; roots	117	32	4.11
	Check plat	145	24	4.22
19	Acid phosphate, ammonium sulphate, and copper sulphate; tops	156	12	4.57
20	Acid phosphate, ammonium sulphate, and copper sulphate; roots	144	20	4.27
	Check plat	144	28	4.11
21	Acid phosphate, ammonium sulphate, copper sulphate, and potassium sulphate; tops	111	10	4.34
22	Acid phosphate, ammonium sulphate, copper sulphate, and potassium sulphate; roots	152	16	4.56
	Check plat	127	28	4.02
23	Mercuric chlorid (1-4,000); tops	....	....	....
24	Mercuric chlorid (1-4,000); roots	100	11	4.25
	Check plat	120	40	4.10
25	Potassium permanganate, ferrous sulphate, and sulphuric acid (1-3-10-600); tops	112	17	4.24
26	Potassium permanganate, ferrous sulphate, and sulphuric acid (1-3-10-600); roots	100	17	3.96
	Check plat	48	5	4.21
27	Acid sodium arsenite (1-10,000); tops	10	1	4.10
28	Acid sodium arsenite (1-10,000); roots	70	22	4.08
	Check plat	105	31	4.11
29	Potassium sulphate and magnesium sulphate (1-40); tops	119	41	4.04
30	Potassium sulphate and magnesium sulphate (1-40); roots	105	21	4.19
	Check plat	136	28	4.06

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[1] The fertilized plat is a part of a large plantation pineapple field, and on two occasions the plantation laborers inadvertently removed the prime, ripe fruits from each row. It is thought, however, that the results of the remaining fruits are sufficiently reliable for use since approximately equal percentages were taken from each row.

[2] Application to tops was made by spraying 1 pound of solution upon each plant.

[3] Application to roots was made by pouring 1 pound of solution about the base of each plant.

PAPAIN-EXTRACTION EXPERIMENTS.

During the year samples of papain were extracted from papaya fruits and sent to an eastern drug company. The quality was declared to be greatly superior to that on the market. Cheaper and more effective methods of extraction must be developed, however, before the industry will be commercially practicable in Hawaii. A grove of 40 papaya trees has been planted to furnish the necessary papaya fruits for further work in this connection.

HAWAIIAN STARCHES.

Pure samples of starch from the tree fern, sweet potato, cassava, and edible canna have been made. Physical and chemical tests will be made to compare them with the commercial starches that are found on the market. The home demonstration collaborator of the station is preparing recipes for the use of each of the starches. It is hoped that as a result of these investigations with Hawaiian starches the islands will export rather than import this material in the near future.

Samples of starches extracted from the edible canna, sweet potato, cassava, and Irish potato were analyzed at the Haiku substation and found to be of excellent purity. The analyses of the residues, however, indicate a very low percentage of extraction. Analyses were made of the residues of the edible canna, sweet potato, and Irish potato to determine the amount of starch remaining after commercial extraction, and the results were found to be 70.85, 69.5, and 64.95 per cent, respectively. A study is being made of the entire process of extraction to devise methods of getting a more nearly complete recovery of the total starch. The starch-extraction machinery at the station consists of a shredder, a perforated screen through which the starch is washed by water that is played upon the pulp, and settling tanks in which the starch is rewashed. Owing to the relatively small percentages of the constituents other than starch found in root crops, and the large quantities of water used in the extraction and washing of the starch, only traces of protein, fat, and ash remain, and crude fiber is the only impurity found in appreciable amounts. The following table shows the results of extracting starch from some Hawaiian root crops:

Analysis of commercially extracted starches.

Material.	Water.	Crude fiber.	Starch.
	Per cent.	*Per cent.*	*Per cent.*
Edible canna	18.73	0.10	81.2
Sweet potato	15.66	.22	84.3
Cassava	15.91	.28	83.6

TREE-FERN STARCH.

During the year the station started experiments with the tree fern for the production of starch (Pl. VIII, Fig. 1). A company in Hilo is producing tree-fern starch for commercial purposes. The tree fern is found scattered over the windward slopes of nearly every mountain on the islands. It is estimated that there are 400,000 acres of tree-fern forests on the island of Hawaii alone. A very large part of this is within the forest reserve or Government-owned lands, from which it is illegal to cut the tree fern. There is enough privately owned land, however, which can be purchased for building up a starch-producing industry of considerable size.

To manufacture the starch the tree fern is first cut and the outer bark is slabbed off in the forest. The core of the average size fern weighs from 50 to 70 pounds and is nearly pure starch (Pl. VIII, Fig. 2). Pure tree-fern starch is obtained from the core by the same process that starch is manufactured from the potato; that is, by shredding the core, screening to remove the fiber, washing the starch, and finally by drying. It can be used as a substitute for cornstarch or for other purpose. Efforts have been made to demonstrate the possibilities of this food product by means of window displays, commercial-club lunches at which tree-fern dessert is served, and in other ways. Assistance is also being given in studying the details of manufacture. Only 50 per cent of the starch was recovered in the process of starch extraction. The product is an excellent starch and resembles arrowroot in many respects. The following table shows that its purity compares favorably with other starches on the market:

Composition of tree-fern starch compared with that of other commercial starches.

Material.	Water.	Crude fiber.	Starch.[1]
	Per cent.	*Per cent.*	*Per cent.*
Tree-fern starch [2]	17.9	0.09	82.01
Do.[3]	16.43	.14	83.43
Cornstarch	12.78	.12	87.1
Arrowroot	17.14	.06	82.80

[1] Calculated by difference. [2] Received August, 1920. [3] Received January, 1921.

If the tree-fern starch industry is to become a permanent one in Hawaii, some method of replanting the cut-over areas must be adopted. Three experimental plats have been established in the Puna district on the island of Hawaii for the study of the propagation of the tree fern. Cuttings from different parts of the fern have been planted. It is believed that an average of three plants can be obtained from each tree fern that is cut.

The rate of growth of the tree fern is also of fundamental importance. Residents of the district vary in their opinion from 10 to 50 years regarding the length of time the tree fern requires to reach maturity. If the time exceeds 20 years it is hardly likely that there are sufficient available tree ferns on the islands to maintain an industry until the replanted areas can furnish new material. On the other hand, if a tree 8 feet tall can be grown in 15 years, and three successful plantings can be made for every tree fern that is cut, a permanent and increasing supply could be assured. A method of determining the age has been worked out by the station, but its accuracy needs to be tested by actual yearly measurements. It is believed that the tree fern in this district makes an average yearly growth in height of from 6 to 8 inches. It would seem advisable to make the vast tree-fern sections of the islands the main starch producing areas, since they are of very low pasturage value and not adapted to tillage. This is, of course, dependent upon the development of satisfactory methods of reforestation of the cut-over areas so that the mountain slopes would be covered at all times.

PRESERVATION OF HAWAIIAN FRUITS AND VEGETABLES.

The station has succeeded in solving many problems for the local canners. The canning industry, other than pineapple canning, is still small, but it offers an increasing outlet for Hawaiian fruits. Jars of Hawaiian jellies, jams, and preserves, together with canned fruits and vegetables, and recipes for each, are being prepared for Territorial exhibits and for demonstration purposes. An attempt is being made to develop a simple inexpensive apparatus for household use in jelly making.

Experiments on drying Hawaiian fruits have been continued. The purpose of this work is to encourage the industrial development of dehydrated Hawaiian fruits. A small laboratory drier has been installed at the station for the purpose of experimentation and demonstration. It is felt that there is very little need for the home drying of vegetables in Hawaii because they can be had fresh nearly the year around. Considerable interest is being manifested in the commercial drying of bananas, and growers are hoping to find some profitable means of disposing of their cull bananas. The recent marine strike has been instrumental in emphasizing the need of drying as a safeguard against transportation difficulties. Effort is being made to induce some commercial dehydrating company to install an experimental plant with some local company to demonstrate the feasibility of commercially drying Hawaiian products. There is some prospect of success in the commercial drying of vegetables, especially on those remote areas which have been set aside by the Hawaiian Homes Commission Act recently passed by Congress.

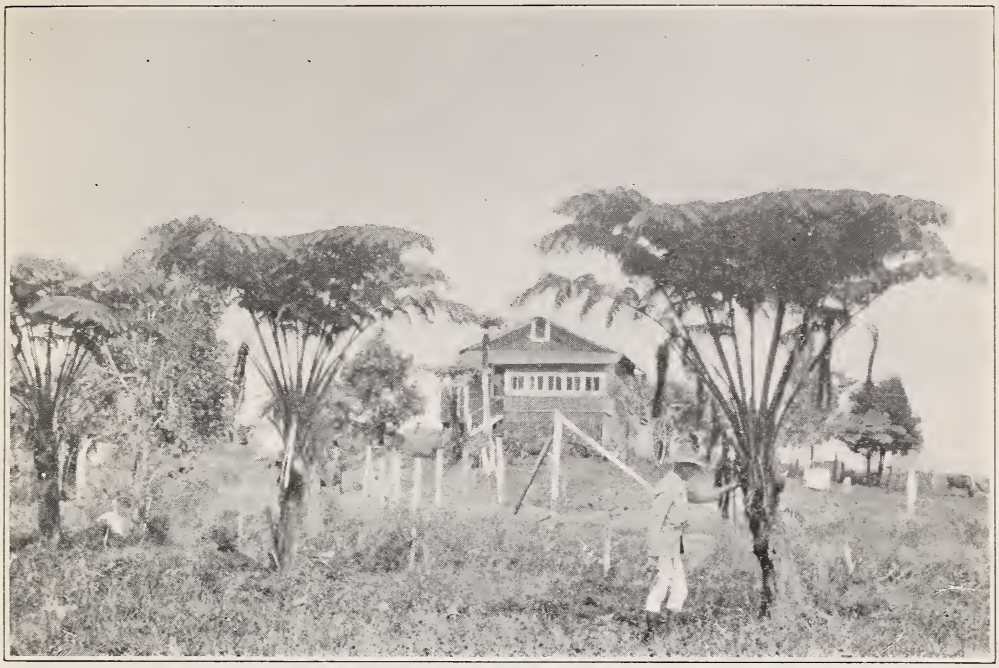

FIG. 1.—TREE FERNS USED FOR STARCH PRODUCTION. PLANTED AT GLENWOOD SUBSTATION IN 1913

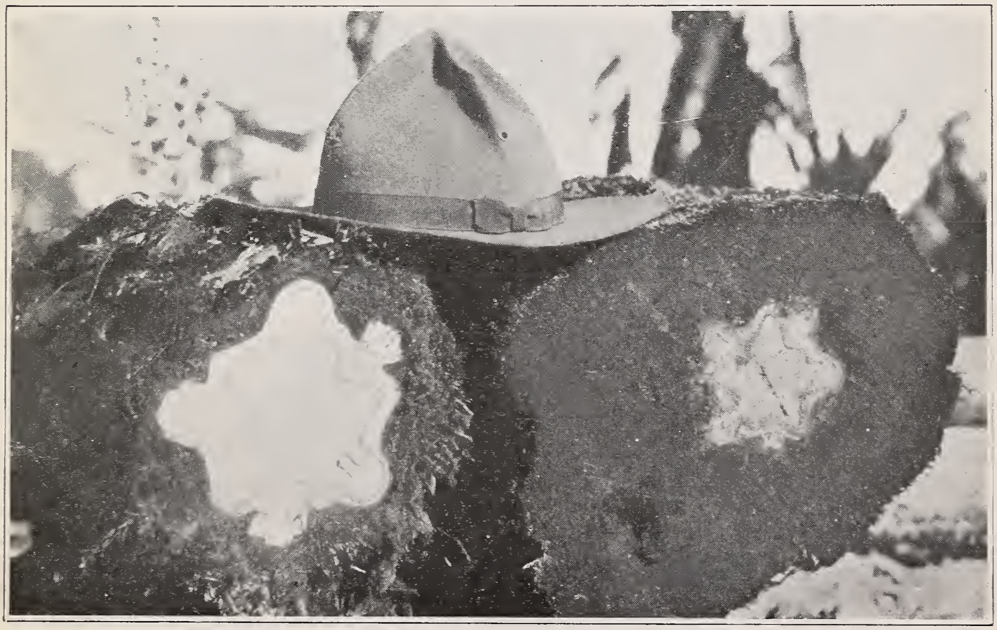

FIG. 2.—SECTION OF TRUNKS OF TWO VARIETIES OF TREE FERNS. LEFT, HAPU; RIGHT, HAPU III.

EFFECT ON CROPS OF BRACKISH IRRIGATION WATER.

Numerous requests were received concerning the tolerance of local crops to brackish irrigation water. A great deal of the water from wells is drawn from near or below sea level, and consequently tends to become brackish if the well is pumped too hard. No data are at hand regarding the salt limit of most of Hawaii's crops. The maximum concentration for sugar cane, however, is said to be from 40 to 50 grains of sodium chlorid per gallon. Alfalfa and corn have been found growing vigorously with water containing 58 grains per gallon. Some new wells, which were recently dug and which are being used, contain as high as 108 grains of sodium chlorid per gallon. There is evidence of a cumulative effect on some lands where old alfalfa is growing, but where it is impossible to get a new stand. Samples of sweet potatoes when analyzed were found to contain as high as 0.74 per cent (2.94 per cent dry weight) of sodium chlorid and had a distinctly salty taste. It is planned to continue work with pot experiments as well as with field tests to determine the tolerance of certain crops to brackish water and to ascertain the cumulative effect after long-continued use of brackish irrigation water.

REPORT OF THE EXTENSION DIVISION.

By F. G. Krauss.

INTRODUCTION.

In view of the fact that the superintendent of extension presented his resignation to take effect shortly after the close of this fiscal year, the seventh year since he inaugurated the work, a brief review of his work is given herewith.

Agricultural extension work was definitely inaugurated in Hawaii in November, 1914, for the purpose of furnishing the practical farmer with the available agricultural data accumulated by the United States Department of Agriculture, the various State experiment stations, and other agencies. The work was authorized by Congress, which added a fund of $5,000 to the regular appropriation of the Hawaii station. In 1919 this sum was increased to $10,000. Previous to this the extension work was largely supported from funds provided by local subscriptions and appropriations by the Territorial Legislature. The limited funds necessitated close cooperation between the station's specialists and the up-to-date, representative farmer-collaborators who are engaged at a nominal sum to demonstrate the most approved agricultural practices in their respective communities and in the outlying islands.

Through the efforts of the superintendent of extension the farmer has been given every assistance in the establishment of better markets for crops and in the development of standard grades of products to meet the demands of the best buyers. Farmers' associations have been formed for the benefit of those living in remote agricultural districts, and careful attention has been given to the marketing and utilization of local crops, and to the wisest expenditure of the profits accruing from them. A number of demonstrations have been made in agricultural communities having the greatest need of them. In various localities the work has included efficient systems of rotation of crops that are beneficial to the island; cooperative experiments in dynamiting and in treating soils antiseptically in pineapple culture; forage-crop and pasture-grass experiments; a great number of comparative tests of field crops; leguminous crop demonstrations; the development of diversified agriculture on the islands; the working out of satisfactory methods of storage, grading, and marketing of comparatively new crops; and experiments in tillage, planting, fertilizing, green manuring, and drainage. Various groups of farmers have been shown how to draw up contracts with the pineapple canneries and the sugar mills for the disposal of their products.

Deeming it expedient to establish his headquarters in a center tributary to an agricultural community, the superintendent of extension selected two homestead units of approximately 50 acres each at Haiku, island of Maui, as a substation and demonstration farm. Haiku was selected because it is an important agricultural region and is adjacent to flourishing sugar and pineapple plantations. Two large tracts of land have been opened up there for homesteading by the island government and plantation owners. A meteorological station, including temperature, precipitation, and wind velocity observations, was established at Haiku in January, 1916, in cooperation with the United States Weather Bureau. The vast amount of work done at the Haiku substation and demonstration farm has been beneficial not only to the immediate agricultural center, but to the whole island group.

The extension division has been instrumental in improving the live-stock industry of the island, manufacturing various agricultural products, and in distributing seeds and literature. Lectures have been delivered on timely topics, and numerous articles have been prepared for the press. In addition to organizing the boys' and girls' club work, the station has fostered school-garden contests, and assisted the boy-scout work and the Boys' Working Reserve.

EXTENSION ACTIVITIES OF THE YEAR.

During the year a great deal of the superintendent's time was devoted to advisory work, there being an ever increasing demand for his services in this capacity. This work has necessitated greater need for travel than was the case in former years. Two trips were made from the headquarters at Haiku, Maui, over the islands of Hawaii and Kauai, and one over the island of Molokai. In addition, four trips were made to the island of Oahu. In cooperation with the extension service of the University of Hawaii and the experiment station of the Hawaiian Sugar Planters' Association, a lecture tour was conducted over the islands of Hawaii, Kauai, and Maui, where the superintendent addressed many assemblages of school children, teachers, small farmers, plantation men, and townsfolk in country and city. Well organized lecture tours, especially when they are accompanied by good stereopticon views and moving pictures, give a healthy stimulus to the promotion of a broader and more diversified agriculture.

Other phases of wholesome agricultural propaganda in which the extension division took an active part were the agricultural fairs. The third annual Maui County Agricultural Fair, held from October 21 to 23, inclusive, was very well attended and created so much interest and enthusiasm that it has been decided to extend the work to other localities. The superintendent again acted as chairman of the agronomy section, and the boys' and girls' agricultural club work, which was inaugurated with the first annual Maui County Agricultural Fair, was maintained in a flourishing condition. The extension division has invariably taken advantage of every opportunity to make large and comprehensive exhibits at the county and Territorial fairs.

The school and home garden activities of the Territory, which have grown to formidable proportions, have always received the hearty support of the extension division. Thousands of packets of vegetable seeds, cuttings, and rooted plants, as well as fertilizers and insecticides, have been distributed annually from the extension headquarters at Haiku to further this work. Planting, pruning, and spraying demonstrations, together with numerous lectures, have been given both to teachers and school children, proving beneficial to all concerned. The superintendent has gained much useful information concerning vegetable varieties and their behavior under the varying environments to which they have been subjected in these activities. During the year the superintendent again acted in the capacity of judge of the school gardens of the island of Maui.

The persistent efforts of the station to extend dairying throughout the Territory, especially on the sugar-cane and pineapple plantations where thousands of laborers are employed, have met with gratifying results. During the year the extension division was called upon for advice in the planning and equipping of three large, modern dairies in widely separated parts of the Territory, and assisted in having several fine dairy herds, including some outstanding sires, imported into the island. The results of this introduction should become far reaching as time goes on. The division was also instrumental in establishing the first cooperative bull association in the islands.

The work of the division in encouraging the development of the swine industry has been reported upon in former reports. The extension headquarters at Haiku has distributed about 300 head of registered Berkshire pigs during the past five years, with the result that a high grade of Berkshire swine now predominates in the Territory. A similar work has been done in the development of the poultry industry. A large flock of superior Single Comb White Leghorn chickens has been maintained at the Haiku demonstration farm since its establishment.

Probably the most important and far reaching new and high type of agricultural activity sponsored by the extension division is that of growing and marketing choice, pedigreed farm and field seeds. From a very small beginning of growing and selling superior strains of farm seeds at the Haiku substation and demonstration farm in 1914, there has grown a large demand for corn and leguminous seeds, especially of the pigeon pea. Orders for more than 20 tons of pigeon-pea seed (enough to plant 4,000 acres) at $300 per ton were received by the station and passed to accredited growers for filling during the year. Hawaii has ideal conditions for the production of high-grade tropical farm seed, and no doubt could develop a seed trade that would become one of its leading industries were her seed merchants to advertise throughout the world. The production of high-grade seed is one of the highest types of agriculture.

During the year the station received and answered about 1,000 letters relating to the work of the extension division. It also maintained a weekly agricultural page in one of the leading daily newspapers, the superintendent and other members of the station staff preparing original and timely articles for publication. At the Haiku substation and demonstration farm a circulating agricultural library and reading room was placed at the service of the public, and agricultural periodicals of a popular nature, after serving their purpose at the substation, were distributed to the farmers of the islands. The superintendent had charge of the Federal quarantine for the island of Maui and inspected all bananas and pineapples before they were shipped to the mainland. Complete meteorological records were again kept at the Haiku substation.

COLLABORATORS.

In the absence of the usually established farm bureaus and county-agent systems, of which the islands are in urgent need, the employment of representative farmers as collaborators in their respective districts has been both practical and economical. Much credit is due these coworkers for their untiring efforts to give to their neighbors the most approved agricultural practices and supplies of seeds and plants.

Of more recent development, and one from which far-reaching results are expected, is the cooperative buying and selling agency which is being developed in Hilo by J. E. Gamalielson, who was for a number of years collaborator of the extension division at Kaumana, Hilo, Hawaii. Mr. Gamalielson is manager of the Glenwood Creamery Co., a cooperative organization of dairy farmers which was established in 1913 through the efforts of the Glenwood substation. In addition to the above-mentioned business enterprises Mr. Gamalielson has successfully managed a diversified farm of 95 acres at Kaumana near Hilo, where his principal lines of work have been dairying and poultry raising. The report for his business for the calendar year 1920 is as follows:

On every Monday and Thursday of the year butter to the aggregate of 3,183 pounds was marketed for the cooperative organization known as the Glenwood Creamery Co. This butter consisted of that which was left after the local demand was supplied. The average price paid per pound was 73.56 cents, and the total returns amounted $2.341.41. A charge of $120.16 for the year was made for selling the butter. The balance remaining after the freight charges were paid was returned to the farmers. Practically one day in each month was given to billing, collecting, and remitting.

Considerable attention was given to secretarial duties connected with the Rochdale Cooperative Association (Ltd.), of Hilo. The membership roll of this association contains nearly 500 names, including those of farmers, railroad men, school-teachers, and county employees. The association was formed for the purpose of purchasing and distributing general supplies and for marketing farm produce. The business for the year amounted to $126,015.57. The farm operated by this collaborator showed a satisfactory return for the year, as is evidenced by the following statement.

Financial report of the collaborator at Kaumana for the year ending December 1, 1920.

Expenditures.		Receipts.	
Feed for chickens and cows	$1,971.41	Eggs marketed (dozens) 4,648	$4,683.47
Labor pay roll	1,160.00	Butter marketed (pounds) 1,009	787.11
Light, heat, power	109.70	Cream marketed (quarts) 515	501.85
Telephone rent	49.10	Chickens marketed (number) 321	385.84
Rent for pasture lot	100.00	Vegetables marketed	23.66
Taxes and licenses	220.44	Accrued incoming rent on farm land	516.00
House and fence repairs	222.82	Value of chickens raised	500.00
Auto and machinery repairs	199.85	Calves and hides sold	14.15
Gasoline and oil	149.50	Salaries and fees	420.14
Interest and insurance	29.87		
Allowance for depreciation	500.00	Total income for period	7,832.22
		Gain during period	3,119.53
Total	4,712.69		

John de C. Jerves, collaborator at Kalaheo, Kaui, has for many years successfully demonstrated that a small homestead, well located and tilled, can be made profitable. Mr. Jerves introduced the well-known Madeira sweet potato, thousands of cuttings of which he has distributed throughout the Territory. The Madeira sweet potato continues to be one of Hawaii's best culinary varieties. It requires from six to eight months to mature and has yielded an average of over 8 tons per acre for many years at the Haiku substation and demonstration farm. Recently Mr. Jerves replaced a grade herd with a foundation herd of Berkshire swine to obtain pedigreed stock for sale purposes. Dry-land taro, corn, Irish potatoes, beans, and forage crops are grown to the limit of his available area. Mr. Jerves's farm probably raises as great a proportion of the products that are essential to the maintenance of the family and live stock as any farm in these islands.

X. L. Helbush has served as collaborator at the Glenwood substation and demonstration farm, and M. A. Dees has held a similar position in connection with the Haleakala substation and demonstration farm. Mrs. Nellie A. Russell has served as collaborator in home demonstration work, and the report of her activities immediately follows.

REPORT OF HOME DEMONSTRATION ACTIVITIES.

By Mrs. N. A. Russell.

Active home demonstration work was commenced on November 1, 1920, and one day a week thereafter was devoted to the various phases of home economics. A fairly complete collection comprising 62 samples of jams, jellies, and pickles from local fruits and vegetables was made up and placed on exhibition. From two to four recipes each were worked out for Natal plums, papayas, roselle limes, oranges, figs, carambola, pineapples, grapes, and tomatoes.

During December, 1920, and January, 1921, 16 recipes were worked out for the utilization of tree-fern starch, a commercially new local product. An exhibit that was placed in the window of one of the leading grocery stores resulted in many inquiries. To further the use of this home product the leading business men's club was provided with dessert made from the starch. Samples of starch, raw and cooked, were also distributed to all the members of the housewives' league.

In February, 1921, a plan was formulated for furthering extension work by having social workers, plantation managers, and women's clubs assemble at a given center, where the planting, care, and use of desirable fruits and vegetables were demonstrated. This plan met with a very heavy response, and from March to June, 1921, two and sometimes three groups were reached each week. Plants of the fruits being demonstrated were distributed whenever they were available. Products made at home from the fruit or vegetable demonstrated were exhibited on each occasion.

The following are representative of the various groups reached in this work: (1) Eighteen young Hawaiian women, nearly all of whom are married; (2) the members of the Housewives' League; 45 American-born high-school girls of Chinese, Portuguese, Japanese, and Hawaiian parentage, who were affiliated with the Young Women's Christian Association; (4) Filipino and Spanish women factory workers, for whom the services of an interpreter were required; and (5) 48 plantation people, the greater number of whom are white. The results obtained from this preliminary work clearly indicate the need of additional funds for furthering this type of extension activities among the women of Hawaii.

REPORT OF EXTENSION AND DEMONSTRATION WORK ON THE ISLAND OF HAWAII.

By R. A. Goff.

INTRODUCTION.

The extension agent for the island of Hawaii again visited as many as possible of those who are interested in farming, advising them where to secure the best seed and of the variety of seed that is best adapted to the elevation and locality of the farm, the kind of fertilizers to use, and the protective measures to take against crop pests. He also cooperated with organizations which are working to better agricultural conditions in Hawaii.

WORK IN EAST HAWAII DISTRICT.

Since the farmers who have 50 acres or less on the east side of Hawaii are interested principally in the growing of sugar cane, they do not use more than 1 acre for the growing of other crops. Plants or seeds of good varieties of banana, papaya, fig, and other fruits were distributed to them during the year, and a number started avocado and mango seedlings for future budding and grafting. About 50 trees were budded with scions that were received from the station in Honolulu and from D. H. Case, of Maui. Seed and young plants of the station's hybrid tomato, which is practically immune to attack by the melon fly, were secured from H. Shipman and distributed.

Edible canna roots and cassava cuttings were distributed for planting for hog feed, as were also elephant-grass cuttings for both dairy and hog feed. In the Hamakua, North Hilo, and Puna districts the possibilities of the pigeon pea and alfalfa were demonstrated on small plats.

WORK IN WAIMEA DISTRICT.

In the Waimea district, where the system of farming resembles the grain and stock farms of the Mississippi Valley, and where no sugar cane is grown, the station emphasized the necessity of raising live stock which can be fed crops that are grown on the farm. The practice of planting corn and potatoes only for the Honolulu market has resulted in a rapid depletion of the soil. Edible canna and elephant grass are crops that have shown themselves to be especially well adapted to the high altitude and heavy winds of this station. These crops together with corn will eventually form the principal part of the feed for live stock, and it will be necessary to purchase only enough milled feeds to balance the ration. During the year seedling trees were distributed for use as windbreaks to protect the growing crops from the high winds, which weaken their resistance to disease and increase the evaporation of soil moisture.

WORK IN NORTH KOHALA DISTRICT.

Since the erection of the new cannery in the North Kohala district the residents have planted considerable area in pineapples. Demonstrations in destroying weeds with arsenate of soda and in spraying useful plants with ferrous sulphate and ammonium sulphate to stimulate plant growth were given during the year. Corn and alfalfa seed were secured for planters who formerly raised rice. These men were forced to change their crops on account of the present low price of rice.

In the remaining districts of the island the extension work was conducted along similar lines with vegetable growers and with those who are interested in taro, sweet potatoes, and Irish potatoes.

DEMONSTRATIONS IN BUDDING AND GRAFTING SEEDLING FRUIT TREES.

Improved varieties of fruit trees may be obtained from the Honolulu nurseries only at an expense which the average homesteader does not feel that he can afford. The quarantine regulations, which are intended to prevent the spread of diseases and insect pests from island to island, prohibit the bringing in of any young trees until all the soil in which they were grown has been removed. Owing to the expense of and the risk entailed in shipping, an attempt is being made to bud and graft as many desirable varieties of fruit trees as possible and to distribute them to farmers who agree to give them proper attention. The Hilo Boarding School has furnished, plowed, and harrowed a strip of land for this purpose. Approximately 200 mango and avocado seeds were planted during the year, and arrangements were made to obtain a further supply from local hotels and other concerns. It is planned to have boys, who are doing agricultural work in the Hilo Boarding School, actually do work in budding and grafting when the seedling trees are being worked over with improved buds.

BANANA-SHIPPING ACTIVITIES.

Trial shipments of from 50 to 200 bunches of bananas from Hilo to San Francisco direct and by way of Honolulu were continued once a month during the year. Arrangements were made with a firm in San Francisco to receive the fruit and to pay the local growers 3 cents a pound for the bananas when they were landed at the Hilo wharf. By this arrangement the growers assumed no risk for any deterioration of fruit occurring on board ship. Before being shipped the fruit was examined, selected, weighed in the field, and checked at the wharf. This work was carried on to enable the farmers having land adapted to the growing of bananas and unsuitable for sugar cane or pineapples to market their fruit outside of Hawaii where the market is not easily glutted. Reports from San Francisco state that the bananas arrive in good condition when they are properly wrapped.

FORAGE-CROP EXTENSION.

Some of the plantations have enlarged their demonstration plats of alfalfa. One plantation now has 2 acres and another has 5 acres. The alfalfa is cut 10 times a year and fed in the green stage because of the lack of facilities to cure it. Plantings of elephant grass are also being increased. This crop makes a good substitute for cane tops when the grinding season is over and the cane tops are no longer available. Pigeon peas are doing remarkably well up to an elevation of 1,500 feet. On the plantations where dairies are being installed there are being planted enough pigeon-pea plants to supply a large part of the soiling crops for the cows.

DISTRIBUTION OF AGRICULTURAL LITERATURE.

Agricultural page separates, which were edited by the extension division of the Hawaii station and originally published in one of the daily newspapers of Hawaii, were distributed to 1,200 interested readers during the year. Fifty or more copies of the annual report and a number of bulletins were also sent to those requesting them.

COOPERATION WITH INDUSTRIAL SERVICE WORKERS.

During the year the owners and managers of some of the sugar plantations appointed industrial service workers to assist them in bettering the living conditions of their laborers. These service workers were instructed how to care for banana trees growing along fence rows and in gulches, and also how to care for the vegetable gardens and the swine of the plantation laborers. The instructions have been given in turn by the service workers to the laborers.

COOPERATION WITH BOY SCOUTS.

All the boys who wished to qualify for the boy scout merit badge in agriculture were given examinations by the station. Special demonstrations were arranged for the boys who were preparing to take this examination. Plants were propagated by budding, grafting, layering, and by seeds and cuttings. Insect pests and weeds were identified, and the methods for the control of each were demonstrated. Samples of the different kinds of local soil were collected and methods of improving the soil were discussed. Three kinds of seed testers were made and various kinds of seed were tested in them. Farm implements were identified and their uses were learned through the courtesy of a neighboring plantation.

COUNTY AGRICULTURAL FAIR ACTIVITIES.

During the year an effort was made to revive the Hawaii County Agricultural Fair. Committees, of which the extension agent served as a member, were appointed by the president of the Hilo Board of Trade. Plans of exhibition buildings were secured from the Maui County Agricultural Fair Association, and an appropriation of $25,000 was promised by the Territorial legislature provided that an equal amount should be raised on the island of Hawaii. The latter amount has been subscribed in part.

SCHOOL AND HOME GARDEN WORK.

The Star-Bulletin school-garden contest was continued during the year with greater interest than usual among the school children. The extension agent made three visits to the gardens of 19 schools, each garden of which was grown under the supervision of the school principals and in competition with the gardens of the other schools. He also visited 130 gardens which were being grown by the individual pupils at their own homes in competition with similar home gardens being grown by pupils in the other schools. He answered as carefully as possible all questions asked by the young gardeners regarding fertilizers, seed, and the control of pests. Five of the school gardens and all of the home gardens were scored, and the winners in the different districts were given prizes by the Star-Bulletin. The remaining 14 school gardens were scored by another set of judges and also awarded prizes.

AGRICULTURAL EXTENSION MEETINGS.

The superintendent of extension and Profs. D. L. Crawford and L. A. Henke, of the University of Hawaii, spent a week on the island of Hawaii for the purpose of holding a series of agricultural extension meetings in the Hamakua, Hilo, and Puna districts. They received the hearty cooperation of the people of these districts, and as a result agricultural subjects were discussed in the schools during the day and at special meetings for the older people in the evening.

GLENWOOD SUBSTATION AND DEMONSTRATION FARM.

During the year the Glenwood substation and demonstration farm continued to raise live stock and also crops which have been found especially adapted to the Glenwood soil and weather conditions. The lease on both the original 16 acres and the 35 acres that were acquired later was renewed for 10 years. X. L. Helbush, the collaborator in immediate charge of the farm, is fencing in the 35-acre area to facilitate its use as a pasture. He is also repairing some of the old fences. When Mr. Helbush took charge over a year ago, the only dairy animal on the place was a purebred Guernsey bull. Since that time he has obtained nine cows and eight calves and heifers. The flock of purebred White Leghorns now numbers 300 laying hens and some young stock. Trap-nest records are being kept of the layers to determine which strains are the best. Hatching eggs have been sent to homesteaders in the various districts of this island and to poultrymen on the islands of Maui and Oahu. A purebred Berkshire boar, two Berkshire sows, and one grade Berkshire sow were added to the farm during the year. The boar is loaned for service to the farmers in the district, and the young stock is sold as breeding stock. Corn, potatoes, elephant grass, and sorghum seed which were planted have done well. Some of the crops were destroyed by heavy rains in January, 1921. The field of *Paspalum dilatatum*, where the sets were originally planted in rows, improved because of the stooling out of the hills. It is now almost a solid mass, forming a mat so thick that dairy animals can not break through in wet weather, as they continually do on the ordinary local pastures. This is the best pasture grass that has been introduced into the district because it grows especially well in wet weather and is drought resistant also.

HAIKU SUBSTATION AND DEMONSTRATION FARM.

By F. G. Krauss.

INTRODUCTION.

The official residence of the superintendent of extension work since the establishment of the extension division has been the Haiku substation and demonstration farm, which is situated a mile east of Haiku in the heart of the Kuiaha-Pauwela-Kaupakalua Government homestead tract, on the island of Maui. Much of the experimental field work of the Hawaii station has been carried on at this place, which is admirably located for demonstration purposes. Special attention has been given to the growing and feeding of new forage crops that have been found promising in the numerous variety tests made each year at the central station in Honolulu.

PINEAPPLE EXPERIMENTS.

Pineapple experiments were started in 1914, when the substation was established, and have formed one of its most important investigations. The pineapple industry in Hawaii is second only to the sugar industry in size. Its cultural problems have increased in proportion to its rapid development. The Haiku district is the center of an important part of the industry and has made the experimental work of the station of special value. Below are given the conclusions which are based on the original pineapple experiments begun in 1914 and continued to June 30, 1921. Other more recently inaugurated pineapple fertilizer experiments are being carried on in cooperation with the chemistry division.

SOILS.

Soil type is an important factor in pineapple production. The red and gray coarsely granulated and porous soils which characterize a large part of Hawaii's pineapple areas are unquestionably what may be termed typical pineapple soils, since they are best adapted to the crop. Such soils, while they may not prove fertile to other crops, are especially well suited for the pineapple crop, because they are naturally well drained and aerated. The black manganiferous soils abounding in the upland pineapple regions of Oahu, though of fine texture, are among the most productive soils when the plants are sprayed with an iron sulphate solution.

LOCATION AND LAY OF LAND.

Excellent pineapples have been grown on some parts of all the principal islands forming the Hawaiian group. Very fine fruit has been produced from near sea level up to 1,600 feet on both the islands of Oahu and Maui. The most favorable altitude seems to be from 500 to 1,000 feet above the sea. New plants are thriving at an elevation of 1,800 feet in the Makawao district of Maui. The lay of the land does not seem to exert any marked influence on favorable soils. Fruit as fine as that which is grown on the slopes is produced on the extensive plain areas of Oahu.

TILLAGE.

The results obtained at the Haiku substation and observations covering a wide area elsewhere lead to the belief that the most detrimental single factor in pineapple culture is that of working or cultivating the land while it is wet. Land which produced some of the best crops when rationally tilled failed utterly in some experiments when it was plowed in a wet or excessively moist condition. Special stress should be laid on this phase of pineapple culture.

Subsoiling has been found very beneficial, both when applied before planting the crop and as intertillage after planting. High ridging of the plants, especially of the plant crop, is not recommended. Subsoiling and middle busting between the rows, and releveling the soil so that gentle ridges are maintained, provides subdrainage, aeration, and a mellow soil. Severe ridging fails to provide such conditions.

PLANTS.

One can not exercise too great care in selecting the plants. Only strong, healthy parent stock, preferably the plant crop and first ratoon crop, should be considered for planting. The planting of crowns, slips, or shoots will produce equally good crops, other conditions being favorable (Pl. X, Fig. 1). The plants, however, must be gathered at the proper state of maturity. Immature or overripe planting stocks will not produce good crops no matter how fine the parent stock or the soil. When crowns from the tops of ripe pineapples are used, one has, of course, less opportunity for choice, but they should at least be carefully culled before they are planted.

The amount of curing that is necessary before setting the plants depends upon the season and the soil. In midsummer, if the season is dry and the soil is in good tilth, the plants should be set out without being cured. Under these conditions the plants need not be as mature as those planted in a cooler and wetter season. If the plants are over mature they should be adequately stripped of their basal scales or leaves. When shoots are to be planted the butt should be cut away. A sharp knife should be used for this purpose, because hacking may cause bruising.

Pineapple plants should be carefully handled in transit, and never be thrown into large piles where heating of the mass can take place.

FERTILIZERS.

There seems to be little or no doubt that stable manure gives the best results in improving soils which are deficient in plant food or that are of poor texture, or both. Pineapple cannery waste and green-manuring crops are practically of equal value. Chemical fertilizers, however, judging from all the reliable data at hand, seem to produce very uncertain and anything but uniform results. Experiments during the year with nitrogenous fertilizers, including potassium nitrate, ammonium nitrate, ammonium phosphate, ammonium sulphate, sodium nitrate, and dried blood, applied in single and fractional doses and totaling from 200 to 400 pounds per acre as a side dressing apparently have exerted only very slight benefits in developing the plants, which have now (June 30, 1921) been planted eight months. Of all the fertilizers, ammonium sulphate seems to have exerted the greatest influence. In fact, this ammonium salt has given good results in a wide territory.

All the virgin soils of Hawaii give better results in connection with pineapple culture than do soils from which even only one crop has been removed. These results are due to the changes that are brought about in the soil by the destruction of the delicate and complex humus matter. The apparent need of organic matter, in proper amount and kind, led the station to undertake a series of experiments with old pineapple land. The results of these investigations indicate the need of turning under all residual crops of the pineapple and supplying organic matter with green-manure crops turned under at the proper season. The following recommendations for the handling of old pineapple lands, with a view to their rehabilitation, are based on data accumulated to date (June 30, 1921):

As soon as the last harvest of any planting cycle is completed, usually in the late fall, the ground should be prepared for planting pigeon peas. The space between the old pineapple rows should be subsoiled, sufficient power being used to break the soil deeply. The subsoil plow should then be followed by a middle buster, throwing the soil to either side. This will cover the weeds and force débris away from the center. If the ground is very dry and cloddy, it should be allowed to rest until after a good rain. Then a one-horse cultivator should be run along the bottom of the open furrow that is left by the middle buster. Two or three workings may be advisable to prepare a suitable seed bed. If the several cultivations are done at intervals of a week or two, successive crops of troublesome weed seedlings will be destroyed and future cultivations will be reduced to a minimum. One row of the pigeon pea seed should be planted between each two rows of the old pineapple plants. A seed drill that is drawn by a horse should be used for this purpose. Ten pounds of seed will be required per acre. The plants make only spindling growth at first, but after two or three months they begin to close in over the old pineapple débris. At the end of the year nearly all of the pineapple stumps will have rotted. This decayed vegetable matter will mulch and manure the pigeon peas and cause them to make a luxuriant growth. The pods should be picked if there is a demand for seed; otherwise the crop can be pastured or harvested for hay. In any event the crop should be left growing for a period equal to that of the pineapples preceding it. It should then be turned under for green manure and a new crop of pineapples planted. By this time the land will be restored as fully as possible and very economically. At Haiku the pigeon pea crops have yielded an average of approximately $100 net profit per acre a year (Pl. IX, Fig. 1).

PRODUCTION OF STARCH ON A SMALL COMMERCIAL SCALE FROM ROOT CROPS AND CORN.

During the year tests were made with edible canna, sweet potatoes, taro, corn, and two varieties of cassava for the production of starch. All of these crops, with the exception of 20 tons of cassava roots which were purchased at $10 per ton, were grown on a field scale at the Haiku substation. Commercial quantities of starch were produced from these crops and residues (by-products from the manufacture of the various starches) in sufficient quantity to conduct satisfactory feeding experiments with swine and poultry.

The recovery of starch from all the crops tested, with the exception of corn, which was a failure, was approximately 20 per cent, or 400 pounds of air-dried starch per ton of roots as they were weighed at the mill. This is not a very efficient extraction, but it was very fair considering the crude methods that were used in the process. It also emphasizes the importance of utilizing to the best advantage the residue, which retains approximately half of the total starch. This probably largely accounts for the high-feeding value of the residue when fed to swine. The starch was sold at an average price of 15 cents per pound. The remaining pulp or residue, which averaged about 1,600 pounds from each ton of original material as macerated, was made into feeding rations, both raw and cooked, for swine and poultry. These feeding experiments have indicated that the feeding value of the cassava and sweet-potato residue, calculated on a water-free basis, is fully equal to that of corn, when its proportion does not exceed 50 per cent of the total ration fed. This is true especially when either of these two kinds of residue are steam cooked and mixed with corn meal, rice polish, wheat bran and middlings, alfalfa meal, or with finely ground pigeon-pea meal (whole plant), and the whole fortified with from 5 to 10 per cent of blood meal or high-grade tankage. Skim milk and skim-milk substitutes, such as dissolved powdered skim milk and semisolid buttermilk, gave results approximately equal to those obtained from feeding tankage or dried blood, especially with younger pigs. Owing, however, to the scarcity and relatively higher cost of the protein equivalents in milk, it was thought more economical to feed the slaughterhouse products. This probably would not hold good where cheap skim milk is available. The cassava and sweet-potato residues were found to be very palatable to hogs when fed either raw or cooked, as was also the limited amount of taro available, but the edible canna and Irish-potato residues were eaten only when cooked and mixed with standard mill feeds. Poultry ate only limited amounts of any of the residue feeds when ample grain was available, but seemed to relish it when it was fed in limited amounts. All animals fed in these experiments were in dry lots. In two 100-day feeding tests, 5 mature hogs and 10 pigs, the latter averaging about 80 pounds at the beginning of the test, gained from 0.75 to 1.75 pounds per day when fed a ration in which cassava or sweet-potato residue resulting from the starch manufacture did not exceed 50 or 60 per cent of the total ration. The feed was well balanced, however, with part of its protein in animal form. These gains compare favorably with the results obtained over a long period from feeding an equivalent of corn. When the residue is fed much in excess of 50 per cent, the animals, especially the older ones, become logy and somewhat pot-bellied and the flesh apparently loses its firmness. It has been estimated that, on the basis of carbohydrate content (starch), 5,200 pounds of the residues is equivalent to 2,000 pounds of corn.

From the data given above and a rough determination of the costs that enter into the manufacture of the starch, it would seem that an efficient utilization of the by-products should cover all costs of manufacture. The following is a summary of the cost of manufacturing 400 pounds of cassava starch and 1,600 pounds of by-products at the Haiku substation, and the value of the finished product.

Cost of manufacturing cassava into starch and value of products.[1]

Cost.		Value of the product.	
Delivered to mill, per ton	$10.00	400 pounds starch (at 10 cents per pound)	$40.00
Washing and peeling roots, per ton[2]	2.50	1,600 pounds residue as it came from the mill (at $10 a ton)	8.00
Grating washed roots to a fine pulp, per ton[2]	2.50		
Attending to sieves, water-sprinkling device, and settling tanks[2]	2.50	Total value	48.00
Draining settling tank, removing 400 pounds starch, drying, bagging[2]	2.50	Total expense	25.00
Overhead expenses, including water, rental, and depreciation	5.00	Net profits per ton of roots	23.00
Total	25.00		

[1] These figures are largely based on the use of the farm-made equipment.

[2] Labor of one man per day.

The above-mentioned figures are considered conservative, and it is thought that the by-product when fed to swine can be made to cover the entire cost of manufacturing the starch, including the production costs of the raw product.

Starch was also extracted in small commercial lots from sweet potatoes, edible canna, taro, and Irish potatoes.

These experiments were conducted to determine the practicability of the small farmer and the man of limited capital producing starch from his own products and possibly from those of his neighbor.

The growing of cassava, sweet potatoes, edible canna, and possibly other starch-producing plants, and their manufacture into starch, together with the utilization of the residue, can, it is thought, be made a very profitable business if starch continues to sell at 10 cents or more per pound and hogs at 18 cents per pound live weight.

The cost of the starch-extraction equipment at the Haiku substation, exclusive of power and building, was $250. The cost of a 5-horsepower engine to operate the machinery would be about $250, and a rough shed 22 by 24 feet could be built for about $500. The total cost for a small starch factory should not, therefore, exceed $1,000.

BREEDING AND FEEDING EXPERIMENTS WITH LIVE STOCK.

Breeding and feeding experiments and demonstrations with several classes of live stock have been carried on at the Haiku substation and demonstration farm since its inception. One of the most important of these experiments is the work with poultry, which is being conducted by the superintendent of extension and his family.

POULTRY.

In 1913 a flock of 100 selected Single Comb White Leghorn hens (C. H. Wyckoff's Aurora strain) headed by 4 pedigreed male birds, and 24 Plymouth Rock pullets (Owen Farm, Vineyard Haven strain) which were mated to two pedigreed cocks of the same breed, were brought to the Haiku farm for use as foundation stock. All of these fowls had been line bred for several years, no new blood having been introduced into the flock in at least 10 successive years of breeding. From 60 to 200 chickens have been raised each year, and flocks of 100 and 200 mature hens have been maintained through a period of seven years. The stock to-day is as virile and prolific as were its progenitors in the beginning of the 10-year period. This would seem to indicate that close-breeding is not always detrimental. Furthermore, crosses and reciprocal crosses have been conducted between the two breeds for a number of years to establish a type of fowl that would be especially adapted to Hawaiian conditions. No very uniform new strains of crosses have as yet been effected, but some beautiful specimens have been developed. None of the matings of the many crosses effected during the past five years has resulted in uniform vigor in all or even in most of the progeny. As a matter of fact, in so far as the experiments have progressed, the greatest uniformity in vigor, as well as in all other qualities, has been produced in the line-bred fowl. Stress should be laid on the importance of selecting blood lines and types that blend favorably. Undesirable characteristics must be avoided, and desirable characteristics must be intensified. The station knows of no more direct and certain method of establishing uniformity of type than by the use of a rational system of fairly close line-breeding.

Careful feeding and egg records have been kept of 60 select layers of the Single Comb White Leghorn breed during the past seven years. The lowest average annual yield per hen, based on the whole flock's production, was 138 eggs, and the highest, 141 eggs. On the whole, the tendency has been toward improved production. Sixty hens laid 7,796 eggs during the fiscal year ending June 30, 1918, and 8,869 eggs during the fiscal year ending June 30, 1921. The production of eggs in the 1917–18 period was fairly uniform during the two half-years periods. In the 1920–21 period twice as many eggs were laid in the last half-year period (January 1 to June 30, 1921) as in the first half-period (July 1 to December 31, 1920). The first half of the 1918 period was very dry, and the latter half was very wet, the rainfall for the two 6-months periods being 23.28 inches and 68.58 inches, respectively, or 91.86 inches for the 12 months. In the first half of the 1921 period 28.99 inches of rain fell, and during the second half of the period 32.76 inches, or a total of 61.75 inches for the 12 months. Whether wet and dry seasons affect the egg laying of the fowl can not be determined from the limited data at hand, but it is thought that the dry season is more favorable than the wet season for egg laying.

All the flocks under consideration received the same feeding rations during the several years that they have been under test. The morning feed is a standard commercial laying mash containing dry nutrients in the following proportions: Moisture, not over 10 per cent; protein, not under 20 per cent; carbohydrates, 49 per cent; fat, 4.5 per cent; ash, not over 11.5 per cent; and fiber, not over 5.5 per cent. A slightly moist crumbling mass can be had by mixing 6 pounds of the above with 4 pounds of clabber milk. At night the flocks are given 5 pounds of scratch feed consisting of various parts of standard commercial scratch feed, supplemented with cracked corn, pigeon peas, cowpeas, soy beans, and other farm-grown grains. At noon the flock is fed liberal quantities of one or more fresh, green feeds, including beet tops, and roots, cassava roots, sweet potato tops and tubers, alfalfa, finely minced sugar cane, and the like. Grit, oyster shell, and charcoal, and fresh water are kept constantly before the flocks. The 60 hens have been maintained continuously on a one-tenth acre lot planted to pigeon peas, intercropped with papaya trees, and Tabasco pepper bushes, which supplied abundance of shade and some supplementary feed and condiments. Whenever soft-shelled eggs appear, a sufficient quantity of fresh lime is slaked in the drinking water to make a saturated solution.

The poultry work, which is being carried on by the New Era homestead farm, under the auspices of the Haiku substation, is one of its most profitable undertakings. The average net profit per hen per annum over a period of five years approximates $2.25. In two successive years, both the White Leghorns and the White Plymouth Rocks have carried off first honors at the Maui County Agricultural Fair.

SWINE.

The New Era homestead farm, under the auspices of the Haiku substation, has maintained from 1915 to 1920 a herd of registered Berkshire swine, consisting of 10 brood sows and 2 herd boars. Breeding and feeding experiments and demonstrations similar to those carried on with poultry were undertaken with swine. As a result of these experiments one or more grand championships were won at three Maui County agricultural fairs against the keenest competition of imported and locally bred stock.

DAIRY HERD.

During the greater part of the station's existence a herd of from 4 to 12 purebred and high-grade dairy Jersey cows were maintained for feeding experiments. The results of these experiments were published in one of the local daily newspapers, and the complete data will probably be issued by the station in bulletin form. The experiments have shown that pigeon peas as a roughage, and dried and ground cassava-root meal as a concentrate, have a high feeding value; and that, on the other hand, fresh sugar cane, whether fed whole or finely minced, has a low feeding value for milk cows. Fresh sugar cane is very palatable and may be fed to some extent, provided that it is mixed with other roughage such as cowpeas, pigeon peas, and the like, but it can not be profitably utilized as the sole roughage for dairy cows under high production.

GOATS.

Breeding and feeding experiments with goats have been under way at the station for one year only. The present herd consists of

Gretel's Son, No. 1554,[9] a purebred registered Toggenburg buck of very fine breeding; two half-breed Toggenburg does, litter mates that were bred to the above-mentioned buck; and the progeny of these two does. (Pl. IX, Fig. 2.) The progeny, two pairs of female kids, were dropped on April 9 and 10, 1921. El Chivar's Hertha, No. 1023, a fine, registered Toggenburg doe having a record of 1,880 pounds of milk and 58 pounds of fat in her fifth lactation period, was unfortunately killed by falling from a cliff. A number of outside grade and native does were bred to the herd buck, and the progeny of four of these does was recorded for further observation.

During the year numerous comparative tests were made of the pigeon pea and other crops to determine their value as green and cured feeds for milk goats. The results show that the pigeon pea is extremely nutritious and palatable and that it is a most efficient and economical roughage feed. It is unreservedly recommended for planting for this class of stock. Corn meal and mill feeds were found to be excellent concentrates.

MISCELLANEOUS CROPS.

Three varieties or strains of sugar beets were grown at the Haiku substation during the year and by several collaborators on the islands of Oahu, Hawaii, and Maui. The results of the plantings at Haiku were very satisfactory. The beets were planted on old pineapple land to which a mixture of equal parts of super and reverted phosphate was applied at the rate of 1,000 pounds per acre in the drill at the time of planting the seed. The beets were planted on November 24, 1920, and harvested on June 23, 1921. The following table gives the results of the variety test with sugar beets:

Results of variety test of sugar beets.

Strain.	Weight of green tops per acre.	Weight of roots per acre.	Calculated sugar yield per acre.[1]
	Pounds.	*Pounds.*	*Pounds.*
Michigan	5,241	24,458	4,594
Klein Wanzleben	12,229	27,952	4,918
Idaho	6,988	26,205	4,054

[1] Owing to an oversight the beets for analysis were not weighed separately when dug. In the week that intervened before analysis could be made, it was estimated that the beets lost 15 per cent moisture. The sugar yields have been calculated on this basis.

As a dairy feed, these beet roots and their accompanying tops have made a most excellent feed, and they should be given at least a trial planting by all dairymen who are well located. Had the season been favorable in regard to rainfall, or had facilities for irrigation been available, it is thought that much larger yields would have been produced.

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[9] This goat is a half brother of California Gretel, the milk goat which established the world's record in 1917, when she produced 2,941 pounds of milk.

Forage-crop work continued to be one of the major projects of the substation (Pl. X, Figs. 1 and 2). The Merker and Napier grasses, both of which have gained rapidly in favor during the last three years, are ready for cutting long before either the Uba cane or the best forage sugar cane is mature. The variety Yellow-Tip, on account of its heavy "lallying" or branching habit, is considered the best forage sugar cane. The sugar-cane varieties are very much relished by the substation cattle, and they are considered of high value as forage, especially if harvested at the best period of growth and thoroughly shredded. The following table shows the yields obtained at the Haiku substation and demonstration farm from new select plantings made on November 24, 1920:

Yield in pounds per acre of green forage harvested from crops planted on November 24, 1920.[1]

Variety.	First cutting, Mar. 28.		Second cutting, May 31.		Third cutting, June 27.	
	Fertilized.	Unfertilized.	Fertilized.	Unfertilized.	Fertilized.	Unfertilized.
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
Yellow-Tip cane	40,800	34,850	38,250	26,350	(2)	(2)
Uba cane	34,850	22,590	24,650	8,500	(2)	(2)
Napier grass	31,450	23,800	36,850	13,600	31,400	19,350
Merker grass	19,550	17,000	27,250	14,450	30,750	23,850

[1] Calculated to acre yields from 200-foot rows, spaced 5 feet apart.

[2] Not harvested.

The first cuttings of all the grasses were made approximately 100 days from the time of planting. At this period the Yellow-Tip cane gave the heaviest yields, totaling approximately 20 tons of green forage per acre. Uba cane gave 17 tons, and Napier grass 15½ tons, and Merker grass approximately 10 tons. The latter grass grows fastest in height, but is spindling in its growth and deceptive as to yield. In the younger stages of development, and when it is well established, Merker grass closely resembles Napier grass. The former flowers several weeks earlier than the latter, and at that stage of its development its stems are harsh and bamboolike. Napier grass is much more succulent throughout its development, and it is considered the better of the two grasses. Both grasses make a much better growth during the dry weather than do the sugar canes.

Edible canna has shown itself to be a valuable forage crop during the past half year of extremely dry weather. When fertilized with 250 pounds of phosphatic fertilizers per acre, applied in the furrow at the time of planting, the plats yielded twice the quantity of forage and tubers that the unfertilized plats produced. The average yields during the past summer were 20 and 10 tons, respectively, of tubers and about an equal amount of leafage. Both the foliage and tubers make excellent feeds for dairy cows, and when cooked the tubers are fairly good for pigs.

The cassava crop has maintained a high place among the many forage crops being grown at the substation. The Wiebke variety, which was introduced from the island of Kauai and grown in a comparative test with eight other varieties, continues to hold its own as to quality and yield. However, at least two of the varieties, which were imported from Java through the efforts of Prof. J. F. Rock in 1918, are very promising on account of their large yield.

Culinary and field beans, Irish potatoes, and corn continue to be important crops, especially from the standpoint of developing pure and improved strains. The corn crop of the year was the poorest in the history of the station, owing to unfavorable conditions. A comparison was made to determine the weevil resistance in storage of the New Era Bantam Yellow Flint poultry corn (S. P. I. No. 45903) with two varieties of local yellow dent and one white dent corn. The yellow flint corn showed comparatively little injury from weevil, but the dent varieties were very much eaten at the end of a 4-months' period of serious infestation.

After many tests with pop corn, some success was had for the first time during the year. Seven varieties were tested in comparison, and the following results were obtained from 100-foot rows of each variety: Black Beauty, 4½ pounds of ear corn; Yellow Hull-less, 2½ pounds; White Rice, 1¾ pounds; and Queen's Golden, 1¼ pounds. Australian Hull-less, New Golden Rice, and Pure Gold each yielded a fraction over a pound. The yields were small, owing to an extremely unfavorable season for corn.

HALEAKALA SUBSTATION AND DEMONSTRATION FARM.

By F. G. Krauss.

INTRODUCTION.

The Haleakala substation and demonstration farm is situated on the island of Maui, in the heart of a promising homestead tract on the slopes of Haleakala, a giant extinct volcano. The land on which the substation and demonstration farm is located consists of approximately 50 acres that were set aside by the Territorial Commissioner of Public Lands in 1918; and through the efforts of Gov. Charles

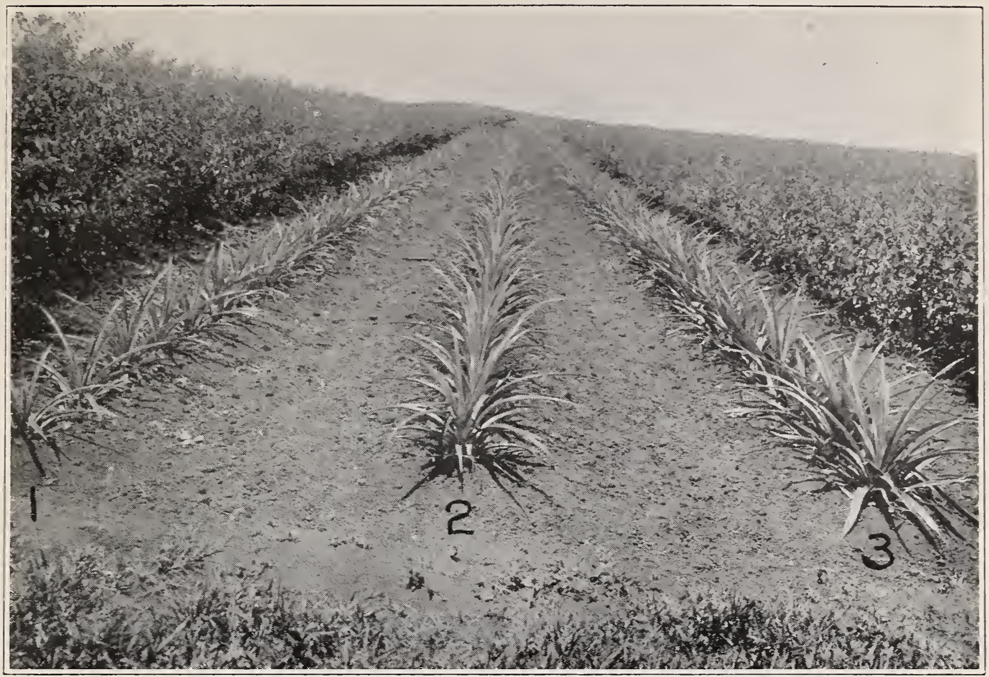

FIG. 1.—OLD PINEAPPLE LAND REJUVENATED BY PLOWING UNDER PIGEON PEAS. LEFT TO RIGHT, PLANTED WITH PINEAPPLE CROWNS, SLIPS, AND SUCKERS.

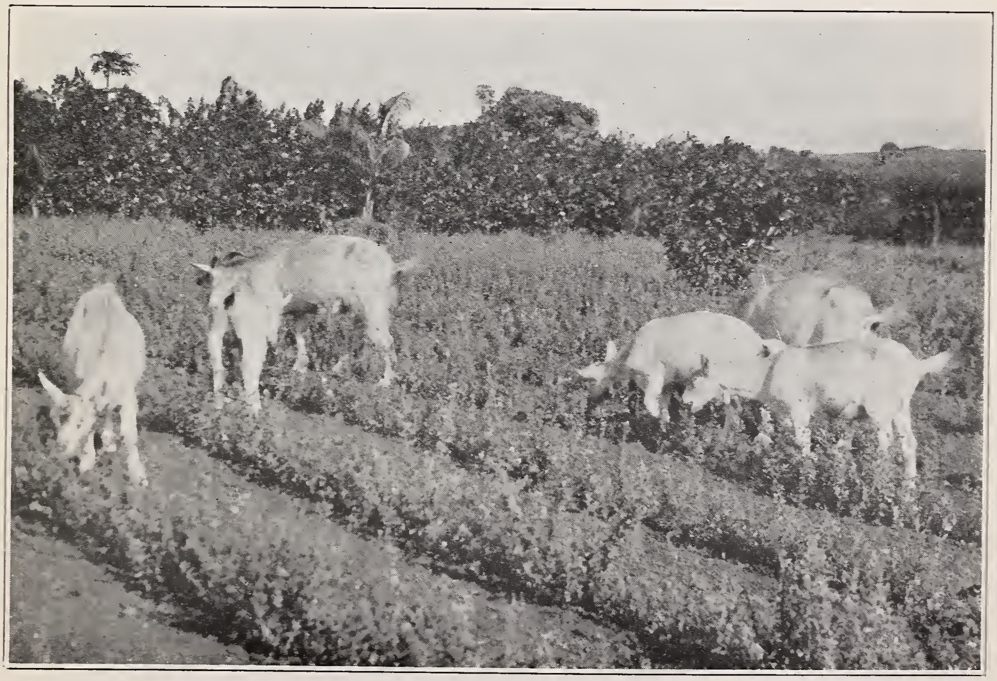

FIG. 2.—STATION HERD TOGGENBURG MILK GOATS FEEDING ON ALFALFA. HAIKU.

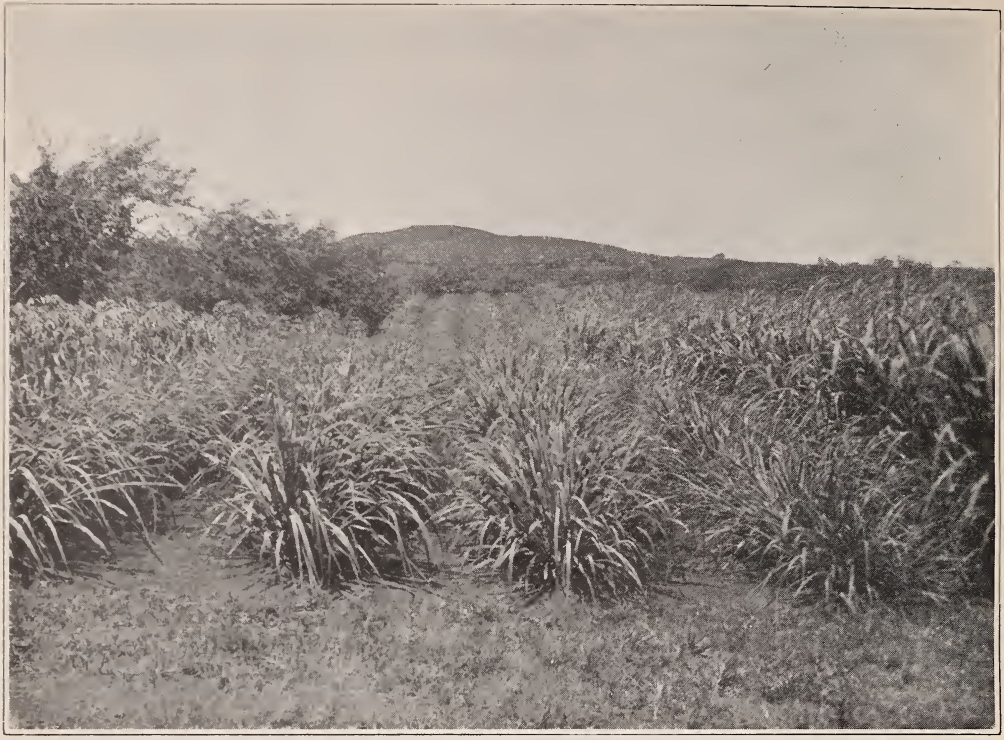

FIG. 1.—FORAGE PLANT INVESTIGATIONS. TWO ROWS ON LEFT, YELLOW-TIP CANE; CENTER ROWS, UBA CANE; RIGHT, NAPIER OR ELEPHANT GRASS.

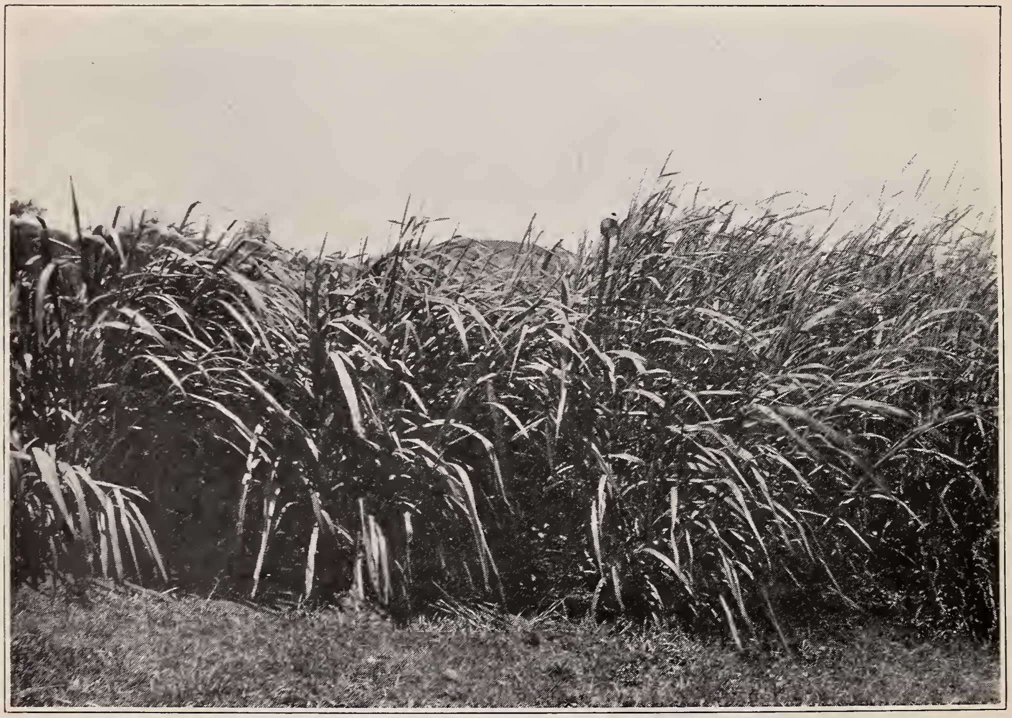

FIG. 2.—NAPIER OR ELEPHANT GRASS ON LEFT. MERKER GRASS ON RIGHT. THREE CUTTINGS OF EACH AS COMPARED WITH TWO FOR CANE VARIETIES SHOWN ABOVE.

J. McCarthy,[10] the sum of $5,000 was appropriated for the construction of the farm buildings which are now being used by the collaborator having immediate charge.

The object of this substation and demonstration farm is to conduct experiments and demonstrations for the benefit of new farmers, many of whom take up homesteads without the necessary capital to justify them making what may prove to be costly experiments in crop production. Climatic conditions vary so in the different districts that what may succeed in one section may not succeed in a neighboring locality. Experiments at the substation will show in the shortest time possible just what can be produced under the somewhat peculiar conditions of soil, rainfall, elevation, and exposure to wind. The establishment of this substation therefore marks an important advance in the development of the homestead districts of the islands.

MISCELLANEOUS PLANTINGS.

Owing to the very heavy rains which fell in the early part of the season and to the severe drought which followed, the year was most unfavorable for the crops growing at Haleakala. Notwithstanding these facts, an acre of pigeon peas that were planted in the fall of 1919 has continued to thrive and to seed heavily. In the fall of 1920, half an acre was planted in Italian lupines, which have made satisfactory growth and have yielded over 200 pounds of prime seed. The crop residue was plowed under as green manure. Edible canna, though it has made slow growth, has produced a fair yield of edible tubers. Three 100-foot rows, each of which was set 5 feet apart, yielded 385 pounds, or at the rate of about 6 tons of tubers per acre during the year. It is thought that closer planting and a longer season for growth at this high elevation would result in a still larger yield. Fully 20 tons per acre have been produced at the Haiku substation at an elevation of 500 feet, and 40-ton yields have been recorded at the central station. The tubers when cooked make an excellent hog feed, and the foliage, that is, the stems and leaves, which about equal the weight of the tubers, make excellent feed for dairy cows. Previous experiments with two varieties of cassava, when compared with the results obtained with edible canna, seem to indicate that the edible canna is the more profitable crop to grow on these lands. Several unsuccessful trials were made with sweet potatoes during the year. The failure is thought to have been caused by the land, which is very much exposed to the elements, becoming very cold in the rainy season and excessively dry in summer. It is planned to test several varieties of sweet potatoes next season, both with and without fertilizers. In these experiments advantage will be taken of the shelter provided by well-established rows of both Uba cane and pigeon peas. Observation leads to the belief that success on a large portion of these lands depends upon shelter belts. Eucalyptus or other trees should be planted on the windward boundaries, and rows of Uba cane and pigeon peas should be spaced throughout the fields so as to permit of intercropping with less hardy crops.

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[10] Governor McCarthy set aside representative units in Territorial homestead tracts for demonstration farms to be used for the benefit of the homesteaders of the particular tract in question. The Haleakala substation and demonstration farm is located on one of these tracts.

Two plantings of pineapples, including crowns, slips, and shoots that were selected from both the low and the high lands of the Haiku district, have been made at the Haleakala demonstration farm. The first planting was made in September, 1919, and proved a total failure. The second planting, made in August, 1920, is growing slowly, due, no doubt, to the unfavorable seasons and the high altitude (2,000 feet). The deep gulches, which are a striking feature of these islands, have been found admirably adapted to banana culture. During the year there was set out an initial planting of 600 select dwarf Chinese or Cavendish banana plants and a few available plants of the Bluefields variety. It is intended to extend these banana plantings on account of the increase in the demand for choice fruit and the improvement in the prices paid for them. Maui should become an important district for growing and exporting bananas when transportation facilities between Hawaii and the mainland improve.

Dry-land taro and vegetables in large variety also were found to thrive much better in these protected and fertile mulch lands than on the raw, exposed uplands. Large crops of several species of wild Rubus, the "akala" berry of the Hawaiians, and an excellent blackberry are maturing in great abundance in the native forests near by. If these crops can be cultivated for commercial purposes, the once supposedly waste lands will prove valuable assets to the Territory.

CORN VARIETY TEST.

In February, 1921, 11 varieties of corn, including the Kula type, were planted on 8 acres of land. Part of the area planted to each variety was fertilized by the application of 500 pounds per acre of of a mixture consisting of equal parts of acid phosphate and reverted phosphate. This mixture had given the most benefit in former experiments and again proved very effective. Only the Kula type of corn thrived, and this on the land that was fertilized. The results of this trial and of previous tests, made both at the demonstration farm and in experiments carried on in cooperation with some of the farmers in the vicinity, would indicate that on these lands farmers should adhere to the long-established Kula type of corn, and to apply in the drill rows, at the time of planting, 500 pounds of a fertilizer compound composed of equal parts of super and reverted phosphate.

POULTRY.

Poultry does exceptionally well on the open range of the northern, middle slopes of Mount Haleakala, where the demonstration farm is located, and success has been had with flocks of the Buff Orpington, Light Brahma, and Black Spanish fowls, as well as with the Bronze Turkey. All of this stock fairly revels in the pigeon-pea rows, which protect them from the raw winds of winter and the scorching sun of summer, both of which are detrimental to poultry. Furthermore, the pigeon-pea plant yields a nutritious grain and green vegetable matter at a season when most other herbage is scarce. Under these favorable conditions it seems fully justifiable to extend the poultry projects.

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